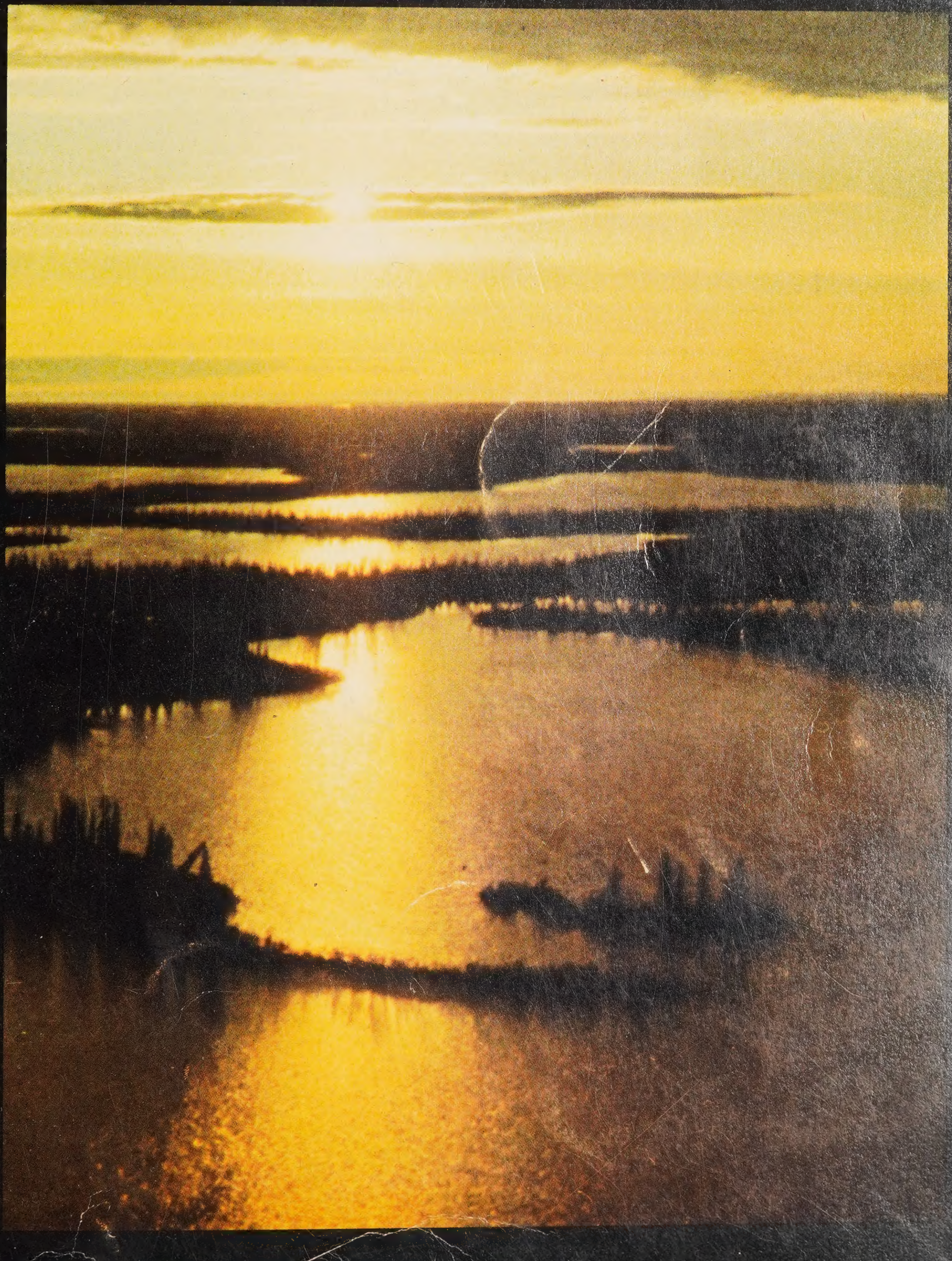
MACKENZIE VALLEY PIPELINE ASSESSMENT

Environmental and Socio-Economic Effects of the Proposed Canadian Arctic Gas Pipeline on the Northwest Territories and Yukon



Pipeline Application Assessment Group

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Canadian Arctic Gas Pipeline on the
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Issued Under the Authority of the
Minister of Indian Affairs
and Northern Development

Ottawa,
November 1974

The evidence submitted to your Committee points to the existence in the Athabasca and Mackenzie Valleys of the most extensive petroleum field in America, if not in the world. The uses of petroleum and consequently the demand for it by all nations are increasing at such a rapid ratio, that it is probable this great petroleum field will assume an enormous value in the near future and will rank among the chief assetts comprised in the Crown domain of the Dominion.

—Report of the Select Committee of the Senate appointed to enquire into the resources of the Great Mackenzie Basin, Session of 1888

PREFACE

On March 21, 1974, Canadian Arctic Gas Pipeline Limited filed applications with the Minister of Indian Affairs and Northern Development and with the National Energy Board proposing the construction of a pipeline to transport natural gas from Alaska and the Mackenzie Delta to southern markets. A group of experts was assembled by the Government of Canada to make a primary assessment of the application, designed to be generally useful to the government departments and agencies concerned with the application, to the hearings of the National Energy Board, to the interested public, and to a public Inquiry then being established to inquire into and report upon the terms and conditions that should be imposed in respect of any right-of-way that might be granted across Crown lands for the purposes of the proposed Mackenzie Valley Pipeline.

The government's Pipeline Application Assessment Group prepared a list of Requests for Supplementary Information which was sent to the applicant in July, 1974 by the Mackenzie Valley Pipeline Inquiry. These requests were for information which would assist the Inquiry in making its examination and report, having regard to: (a) the social, environmental and economic impact regionally, of the construction, operation and subsequent abandonment of the proposed pipeline in the Yukon and Northwest Territories; and (b) any proposals to meet the specific environmental and social concerns set out in the Expanded Guidelines for Northern Pipelines as tabled in the House of Commons by the Minister of Indian Affairs and Northern Development on June 28, 1972.

The Pipeline Application Assessment Group has also prepared the report contained in this document. Although published under the authority of the Minister of Indian Affairs and Northern Development, this document is not a statement of government policy, nor should it be assumed that the government endorses any or all aspects of the assessment, which reflects only the judgements of the individuals who prepared it.

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NOTES:

1. A number of parts of the text of this report are couched in the future rather than the conditional tense. Under no circumstances is the use of the future tense to be construed as indicating the acceptability or otherwise of the Application.

2. In this report the word "Application" is used to refer to both the Application *per se* and the exhibits in support of the Application.

3. Notwithstanding inferences within the text of the report, this publication constitutes the final work of the Pipeline Application Assessment Group. There will be no further published reports.

CHAPTER 1

GENERAL CONSIDERATIONS

1.1 INTRODUCTION TO REPORT

This report is intended to identify and assess the environmental and regional socio-economic effects that will or may arise in the Northwest Territories and Yukon Territory as a direct or indirect result of the project described in the Canadian Arctic Gas Application submitted to the Government of Canada on March 21, 1974—assuming that the project is permitted to proceed in the manner proposed. This Application, directed to the Minister of Indian Affairs and Northern Development for land, quarry, and water permits and to the National Energy Board for a Certificate of Public Convenience and Necessity, is for permission to construct a Mackenzie Valley gas pipeline to carry natural gas from the Mackenzie Delta area and Prudhoe Bay, Alaska, to markets in southern Canada and the United States. The report has been prepared for the Government of Canada by a group of public servants, convened for this purpose as the Pipeline Application Assessment Group.

In conducting the assessment and in preparing its report, the Assessment Group has followed the general terms of reference outlined below but otherwise has been free to carry out its assessment in an independent manner. The target date for completion of the assessment was six months from the date the Application was received.

1. The assessment is to deal with, and is confined to, environmental and regional socio-economic effects of the Applicant's proposals on the Yukon Territory and the Northwest Territories. The Applicant's statements on alternative routes within the same region are also to be considered. Engineering considerations are involved only insofar as they bear upon the above.

2. The assessment is to review the Applicant's proposals in terms of the concerns of government set out in the "Expanded Guidelines for Northern Pipelines" (1970, 1972).

3. The results of the assessment are to be presented in a public report designed to be of general use to federal departments and agencies, the territorial governments, the Commissioner and participants in the Mackenzie Valley Pipeline Inquiry, hearings of the National Energy Board, and interested members of the public. The findings presented in the report are not to be binding on any department, group or agency.

4. The report will not make recommendations *per se* regarding what should or should not be done; rather it is to identify concerns and interactions, and where appropriate, to describe measures that might serve to reduce or

avoid adverse impacts or increase benefits.

Scope and Approach

The time frame allotted for completion of the assessment has controlled to a considerable degree the scope, detail and nature of the report.

The assessment relates entirely to the Applicant's formal Application, together with the volumes designated as exhibits in support of the Application and submitted on March 21, 1974. The various biological reports issued by the Applicant and the Gemini North socio-economic report (received in July) have been considered as back-up reference material. Moreover, positions taken by the Applicant subsequent to March 21 are not considered, in the present exercise, as modifying the Applicant's formal proposals. For instance, in this regard, the schedule of activities presented by the Applicant in his documents of March 21, 1974 has been used as a time framework in the assessment report, even though the company has indicated that there will be a delay from the schedule proposed in the Application.

During its work on the report, the Assessment Group has had virtually no contact with either the Applicant or with the various groups that have been identified as participants in the Mackenzie Valley Pipeline Inquiry. Moreover, the report is not designed to reflect particular policies of government or positions of interested government departments.

The report consists principally of a series of short papers that explore the potential interactions between the proposed project and the people, economy, and/or environment of the region. It is not suggested that the papers cover every possible concern regarding the pipeline. Given the time frame within which the assessment was to be carried out the topics chosen were those considered by the Group to be of greatest concern. For the most part, they arise from the concerns expressed in the "Expanded Guidelines for Northern Pipelines". Some of the papers are overlapping in subject matter as a consequence of examining the project or the region from different points of view.

A description of the region and the proposed project have not been included in this report. On the one hand, Canadian Arctic Gas Pipeline Limited has provided an extensive account of the project in the exhibits accompanying its Application, and on the other hand, the environmental and socio-economic attributes of the region are described in summary fashion or in detail in a number of published reports. The "Report to the Task Force on Northern Oil Development" prepared under the Environmental-Social Committee of the Task Force and scheduled for publication in December 1974 is particularly relevant in this regard.

The Assessment Group has not gathered new data, rather the assessment and the report are based almost entirely on information at hand from a wide variety of sources outside of the Group and from the specialist knowledge of the participants in the assessment process. The major sources have been the Environmental-Social Program, Northern Pipelines; other government research in the region; studies commissioned by the Applicant (and his predecessors) either directly or through the Environment Protection Board; investigations by other segments of the petroleum industry; investigations relating to the Mackenzie Highway; as well

as pipeline information from Alaska and the U.S.S.R. Of course the group has also been able to draw directly from the experience of some of those conducting research under the Environmental-Social Program.

In spite of the very considerable amount of knowledge that is available from these and other sources, the assessment has encountered some gaps in information. Although many of these involve specific effects of specific actions proposed by the Applicant, others arise from gaps in basic scientific knowledge. Many of these information needs have been identified in the report and in the "Requests for Supplementary Information".

A variety of different points of view regarding the proposed Mackenzie Valley gas pipeline may be taken by different groups of Canadians. These include Native people of the Northern Territories, other Northern residents, the Applicant, the petroleum industry, persons with political responsibility, public servants, business people, tourists, sociologists and environmentalists. In conducting the appraisal the Assessment Group has recognized a wide range of views but has attempted to avoid being dominated by any one particular interest. However, extra attention was given to the situation of Northerners, especially Native Northerners.

Requests for Supplementary Information

In addition to preparing the assessment report, the Pipeline Application Assessment Group was instructed to prepare "Requests for Supplementary Information", designed to elicit from the Applicant further explanations and information required to assist in review and appraisal of the socio-economic and environmental implications of the Applicant's proposals insofar as they apply to the Northern Territories. Although the Applicant commented in his proposals on virtually all the concerns of government expressed in the "Expanded Guidelines for Northern Pipelines", 56 requests keyed individually to relevant sections of the Guidelines were prepared by the Assessment Group. In July 1974 the Inquiry sent these "Requests for Supplementary Information" to the Applicant and to other interested parties. The first replies to some "Requests" were received in October by which time much of the assessment report was complete. Therefore, it has not been possible for the Assessment Group to take into account any new information contained in the responses to the "Requests". The Assessment Group recognizes that some of the comments contained in its report might have been different had it been possible to take into consideration the information contained in the "Responses". Most of the matters raised in the "Requests" are also discussed to some extent in the assessment report but a few have been omitted pending review of the "Responses".

Pipeline Application Assessment Group

The Assessment Group was established by the Government of Canada to prepare a primary environmental and regional socio-economic assessment to serve the interests of all federal departments and agencies, the territorial governments, the Mackenzie Valley Pipeline Inquiry, and other interested agencies. It was anticipated that these various organizations could then adapt the findings of the primary assessment to their own interests and responsibilities.

The Group operates under the Environmental-Social Committee of the Task Force on Northern Oil Development. The full-time technical staff has been largely seconded from the departments of Indian Affairs and Northern Development, Environment, and Energy, Mines and Resources; the Government of the Northwest Territories and the Government

of the Yukon have each had a member on the Group. A substantial number of specialists from government agencies and consultants from outside government have provided advice or contributed to the report. Persons comprising the full-time technical staff, together with other persons who have contributed written material, are listed elsewhere in this report. In addition, the Assessment Group has been assisted in its task by many others in the federal public service, in the territorial governments, and in the private sector, In particular, officers of the Canadian Wildlife Service in Edmonton and of the Fisheries and Marine Service in Winnipeg and Vancouver have contributed substantially to the biological aspects of the assessment. Mr. A.J. Reeve, Director of the Environmental-Social Program, Northern Pipelines, has provided unfailing support and encouragement and has served as an invaluable sounding board in reviewing the report in draft form.

1.2 CANADIAN ARCTIC GAS APPLICATION

The Canadian Arctic Gas Application of March 21, 1974 and the exhibits in support of the Application contain the Applicant's proposals relating to engineering, construction and operation, environmental interactions, regional socio-economic questions, and alternate routes and modes. Proposals required by the National Energy Board concerning such matters as cost, tariffs, gas supply and markets and finance are to comprise a later filing. Both categories of exhibits are listed on the accompanying schedule copied from the Application.

S C H E D U L E 1

TABLE OF CONTENTS OF MATERIAL IN SUPPORT OF APPLICATION

* SECTION 1		GAS SUPPLY UNDER CONTRACT
* SECTION 2		MARKET PROJECTIONS
* SECTION 3		GAS SALE CONTRACTS
* SECTION 4		GAS SUPPLY AREAS
* SECTION 5		GAS SUPPLY RESERVES
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	c	REGIONAL SOCIO-ECONOMIC IMPACT STATEMENT
	d	ENVIRONMENTAL STATEMENT
	e	ALTERNATIVE CORRIDORS AND SYSTEMS OF TRANSPORTATION
	f	NORTHERNER TRAINING PROGRAM
* SECTION 15		FINANCIAL PLANS AND CANADIAN CONTENT
* SECTION 16		PREREQUISITE IMPORT-EXPORT AND OTHER AUTHORIZATIONS

*To be submitted subsequent to the date of this application.

The exhibits in support of the Application are very extensive.** They provide information on virtually all the subjects raised in the "Expanded Guidelines for Northern Pipelines". Although a

**In excess of 6,000 pages of text, maps, flow diagrams, alignment sheets, biological studies and other material are included in the first filing.

vast amount of information is included, the presentation leaves many uncertainties regarding specifics of implementation if the project were underway. The Application provides principles and theory but in many respects lacks specifics of the *modus operandi*; it contains frequent assurances that the subject being considered is adequately understood, that designs will be developed to cope with situations of concern, or that additional studies already planned will remove any uncertainties. This approach is equally inherent in the socio-economic, environmental and engineering components of the submission.

The Application and supporting exhibits include only preliminary, "conceptual" design. The Alignment Sheets show location and terrain parameters, and the reports deal with construction mode and procedures, specifications, quantities and schedule. But the final engineering design will be prepared at a later stage; much specific information required for this design stage has not yet been collected. Therefore, although a large volume of information is presented on which to judge the proposed project, here also the Applicant's reliance on principles and assurances leaves many issues open at this application stage of the project, with basic decisions to follow at the final design stage.

The Applicant's proposed route and facilities are located rather specifically on the Alignment Sheets (Scale 1 inch to 2530 feet) and, although other facilities some distance from the right-of-way are shown less precisely on maps, the general impression conveyed is one of specificity in choice of location. This impression is reinforced by specific requests in the Application to the Department of Indian and Northern Affairs, for grant of right-of-way, purchase of lands, permission to engage in land-use operations, quarrying, use of water, and use of timber. On the other hand some statements indicate that the Applicant considers his locations as tentative and subject to revision. Thus the "Application to the Department of Indian Affairs and Northern Development" makes reference to "general location" and "tentative land requirements" (Page 6, Paragraph 6) and indicates: "As the Applicant does further groundwork and makes further surveys, the extent and location of its land and backfill requirements may be changed."

1.3 ASSESSMENT AND APPROVALS

In conducting its review of the Applicant's proposals, the Assessment Group has assumed that the present Application is for general approval and that any such approval would be conditional upon the Applicant obtaining at later dates, the customary specific approvals under the various applicable territorial and federal legislation. These assumptions imply that the present review of the project is to be based upon the Applicant's present proposals together with such supplementary information as he is able to provide at his present stage of planning, without access to detailed plans, engineering design or construction specifications. Thus the introduction to the "Requests for Supplementary Information" states: "It is recognized that certain project details (for instance engineering design and construction specifications) apply, of necessity, to a later stage, and the present request for additional information attempts to avoid asking for such details." In the context of the above and the limited period of time allowed, the present assessment is confined to such appraisals as are possible from review of the present formal proposals of the Applicant.

The assessments that are outlined in the report involve a critical appraisal or impact analysis of the proposals of the Applicant. Thus, the report tends to focus attention on those parts of the Applicant's proposals that have given rise to concerns, and to take for granted the many parts of the proposals that do not involve concerns. On the other hand, the critique of selected parts of the proposals is aimed at improvement of the total proposal. In fact, the assessments are predicated throughout on the assumption that, if permission should be granted for the project to proceed, the Applicant would implement all proposals contained in the Application (and supporting exhibits) and particularly those that serve to enhance the socio-economic, environmental and engineering "suitability" of the project.

1.4 FINAL DESIGN REVIEW

Many aspects of the proposals of the Applicant available for review in the present assessment are preliminary, and many details will not be available until the final design stage. Hence, the Assessment Group considers that a further review of the Applicant's plans at the final design stage could be of considerable value to government. Such a final design review would permit appraisal of those potentially detrimental effects of the project that cannot be effectively evaluated now. It would also provide an opportunity to determine whether the many aspects of the Applicant's proposals that are now presented as principles or generalizations will give rise to any concerns when they have been converted to specific plans or designs. Moreover, such a final design review could facilitate the appraisals connected with the "approval" process for specific aspects of the project under applicable federal and territorial legislation, and could serve as a reference for construction monitoring.

As indicated above (*see* topic "Canadian Arctic Gas Application"), some matters of concern relative to the environmental and socio-economic effects of the proposed project in the Northern Territories are presently dealt with in principle only, many specifics remain to be worked out, and even locations are subject to revision. In conducting its appraisal, the Assessment Group has found that a definitive assessment of some potential impacts cannot be made on the basis of the Applicant's present proposals. The approach taken relative to such topics has been to focus on the concern and to record the importance of a further assessment when detailed plans, final design, contract specifications and specific research information are available and when some specific matters have been coordinated with appropriate federal, territorial or community authorities. Specific matters that the Assessment Group has identified as deserving particular attention in such a final design review are identified in the "Highlights" part of various topic sections in the assessment chapters, and particularly in those comprising the environmental assessment.

SOCIO-ECONOMIC IMPACT ANALYSIS

CHAPTER 2

NATURE OF THE REVIEW AND PRINCIPAL FINDINGS

Introduction

On March 21, 1974, the Canadian Arctic Gas Pipeline Limited (CAPGL) submitted an application concerning the construction and operation of the proposed Mackenzie Valley pipeline to the Minister of Indian and Northern Affairs and to the National Energy Board. Filing with the Minister of Indian and Northern Affairs related to acquiring "those interests in lands and to receive...all approvals necessary to own and operate a pipeline in the Yukon Territory and the Northwest Territories" (CAGPL, Mar. 1974. "Applications and Summaries of Initial Material"). National Energy Board filing related to obtaining a Certificate of Public Convenience and Necessity. The Applicant's affiliate, Alaska Arctic Gas, simultaneously filed applications with two United States' agencies, the Federal Power Commission and the Department of the Interior. These concerned the 200 miles of the proposed pipeline that would be located in Alaska.

The pipeline system, as described by the Applicant, would involve the installation, during two and a half years, of some 2,600 miles of pipe of which 2,400 miles would be located in Canada. Most of this pipe would be 48 inches diam., although some would be 42 inches and a small amount 30 inches. More than forty compressor stations would be required in Canada and Alaska to ultimately pump a peak intake volume of 4.5 Bcf of natural gas daily. These stations would be installed over a six-year period. In addition, twenty-one new airstrips would be built to provide support for the project, and three existing strips would be upgraded. Wharves, docks and roads needed to transport material to the pipeline right-of-way would require construction or expansion. Peak construction work force is estimated at 8,000 men (Summary, Sect. 13.a, p.1).

The present analysis relates to the socio-economic impact of that part of the proposed pipeline that will be located in the Northern Territories. It has been prepared by a socio-economic unit of the Pipeline Assessment Group consisting of social scientists and specialists drawn from the Department of Indian and Northern Affairs, the two territorial governments and other sources. Together with the companion assessment of the environmental impact of the pipeline, the socio-economic assessment is intended as an initial review of the pipeline Application with respect to matters concerning the Northern Territories.

The present report should not be viewed primarily as a critique of the Application submitted by CAGPL. The intention has been to use the information provided by the Applicant, and other information, as a basis for predicting the nature and direction of the impact of the proposed pipeline on Northern peoples and their present way of life. Material for the report was derived almost entirely from data already at hand, since the Assessment Group had virtually no opportunity to do original field research.

Two points should be kept in mind in reading the socio-economic review. One is that it is very difficult to sort out the possible impact of the proposed pipeline from the consequences of other economic and social events that could also take place in the Study Region during the next decade. The present comments should therefore be viewed as reflecting on the possible combined outcome of a variety of developmental events and processes, among which the most important will be the proposed pipeline. The second point is that the following comments should be viewed as valid only if the pipeline project takes place as is described in the Application; that is, construction of the pipeline will occur within the time-frame that has been indicated, will follow the Prime Route, etc.

As a further point, the validity of any predictions made at this stage must also depend on present (non-pipeline) regional social and economic trends and insitutional patterns continuing on more or less as they are.

What the Report Contains

This report deals mainly with the effects of the Applicant's proposed pipeline, along his Prime Route, on the society and economy of a "Study Region" of the Northern Territories.

The Prime Route, which begins in the natural gas fields of the Mackenzie Delta, follows the Mackenzie River Valley southward through the Northwest Territories. Between Inuvik and Camsell Bend, it closely follows the route that has been chosen for the Mackenzie Highway. It is connected with a pipeline route that extends from Prudhoe Bay, Alaska along the coast to join the Mackenzie Valley route just south of the Mackenzie Delta. Figure 1 is based on one of the Applicant's maps, and shows points in southern Saskatchewan and British Columbia on the Canada-U.S. boundary where the pipeline will connect with United States pipelines.

The Study Region referred to throughout this report is that shown on Figure 1 of Section 14.c of the Application, which is reproduced here as Figure 2. The Study Region contains five Sub-regions: the Northern Yukon; the Lower Mackenzie/Delta; Central Mackenzie; the Upper Mackenzie; and the Slave region. These differ greatly in population and stage of development. The Slave region contains about two-thirds of the population of the Study Region as a whole, which the Applicant gives as 13,329 in 1971. It is the Slave Region in which major northern communities such as Yellowknife, Hay River, Fort Smith and Pine Point are located. The Lower Mackenzie/Delta, in which Inuvik is the principal centre, is also quite populous, having a 1971 population of approximately 3,000. At the other extreme is the Northern Yukon which contains only the small community of Old Crow (Sect. 14.c).

On occasion, this report refers to the geographical regions used as a basis for study in some other reports, for example the MPS and TFNOD reports (*see* Literature Sources following this review). A common characteristic of these other study regions is that they are more narrowly restricted to the Mackenzie Valley proper than is the Applicant's Study Region. They are referred to as the "Mackenzie Corridor Impact Region" in the present analysis. Very approximately, the Mackenzie Corridor Impact Region would coincide with the Applicant's Study Region if most of the Slave Sub-region were excluded from the latter. In the case of some topics that are dealt with in this report, little information was available that was geographically specific to either the Study Region or the Mackenzie Corridor Impact Region. In such cases, available data for the whole of the Northern Territories were used and the geographic focus of the analysis was shifted accordingly, even though

this has lead to some inconsistency of treatment from topic to topic.

Every effort has been made to develop a complete and comprehensive report within the limited time available. However, some issues that have been raised by various individuals and groups were felt to be beyond the scope of the present study. These include topics such as the effects of altering the location or construction schedule of the proposed pipeline, alternative modes of transporting natural gas to market, the impact on the Study Region of major developments in contiguous regions such as Alberta and Alaska, and Native land claims. Even though these topics are not given specific attention in the report, some of their aspects are occasionally mentioned in connection with particular issues under consideration.

Organization of the Report

This report examines the socio-economic impact of the proposed pipeline from three different points of view. At the most general level, the chapter entitled "General Impact Analysis" deals with the broader effects that the pipeline may have on human activity and welfare in the Study Region. It discusses macroeconomic and broad social variables such as changes in population, labour force and the functions of communities. At a somewhat more specific level, the chapter entitled "Sectoral Analysis" is a review of the pipeline's possible impact on a variety of regional activities such as hunting, trapping and fishing; transportation; trade; and education. At the most specific level, the chapter dealing with "Local Impact Analysis" presents a community-by-community account of the physical, economic and social effect that the pipeline may have on particular locations.

The various chapters and sections of the report are not meant to be additive or inter-dependent. The chapters in particular should be viewed as standing independently of each other, and as examining the regional effects of the proposed pipeline from different points of view.

As presented in this report, the views of the Applicant are regarded as being those expressed in the main body of the pipeline Application, and not the views contained in background reports prepared for the Applicant by the Boreal Institute, University of Alberta, and by Gemini North (*see* Literature Sources). For present purposes, both the Boreal Report, which is submitted as an appendix to Section 14.f of the Application, and the Gemini Report, which the Applicant submitted separately, are treated as no more than two of the many sources of information available to the Assessment Group.

Principal Findings

The main points and issues that are raised in the socio-economic chapters are given brief discussion below, under appropriate headings. The discussion is not intended as an over-all summary, since it is highly selective and only points and issues that are of particular significance are included. Moreover, each individual section of the socio-economic chapters terminates with a Highlight sub-section. The reader who wants a quick but detailed impression of what the review says on various topics is referred to the Highlights.

Main Short-to-Medium-Term Effects

Effects that will likely be experienced strongly during peak construction, as well as during the buildup to this peak, are the following:

1. A high level of activity will affect all parts of the region. In terms of the numbers of residents

and non-residents that will be involved, it will be of a much larger order of magnitude than the region has experienced to date.

2. A substantial inflow of labour to the region will result from the pipeline project and associated developments in transportation and logistic support, together with gas-field development, etc. A considerable part of this in-migration will be controlled by the Applicant and his contractors, and firms that are engaged in petroleum activity. In addition, however, there will be an uncontrolled inflow of transients who will be attracted to the Study Region by the prospect of high wages and other income.

3. While the pipeline and closely related developments (including gas-field development) will provide the main impetus for an acceleration of regional activity, oil and gas exploration will also play a very important role. A decision to construct the pipeline would likely have a marked positive effect on oil and gas exploration.

4. During pipeline construction there will be a high level of winter activity and a considerable amplification of present seasonal cycles because pipeline construction, gas-field development, and increased oil and gas activity will be superimposed on the existing seasonal changes in the level of activity and employment.

5. As a consequence of the pipeline, there will likely be a significant increase in the proportion of total income derived by residents of the Region from sources such as wage payments, purchases of local goods and services, etc. However, any such effects of the pipeline will be moderated by the degree to which resident labour and business capacity are already fully employed before the requirements of the pipeline are considered.

6. There will probably be some local price and cost inflation as a result of shortages and bottlenecks that may develop with respect of items such as accommodation, serviced land, etc. This could raise problems for residents of the Study Region whose incomes are relatively low and fixed.

7. Regional business establishments could expand rapidly. A level of capacity might be attained that may not be sustainable following completion of the pipeline.

8. Shortages could develop in the supply of resident labour willing and able to participate in wage employment. All Native people who would want wage employment will probably be able to obtain it for a considerable part of the year during pipeline construction.

9. Relatively high wages will be paid by the Applicant and his contractors in order to attract and retain skilled labour. This could result in rising regional wage costs, and could raise difficulties for small firms that are unable to pass cost increases on through raising prices. Insofar as costs are passed on, problems could arise for consumers, particularly low income Native people.

10. Members of the Native labour force who currently derive a considerable part of their income from hunting, trapping and fishing will likely be confronted with economic and social inducements to take wage employment. This will likely result in a decrease in the number of Native people who still depend strongly on the traditional economy. Of the various economic activites traditional to Native people, it is probable that the strongest decline will occur in trapping.

11. There should be a rapid growth of some of the larger communities of the Study Region, which will be key centres of logistic support during

pipeline construction. Particularly affected will be Inuvik, Hay River, Fort Simpson and Norman Wells.

12. Smaller Mackenzie Valley communities may supply labour to the pipeline. For a variety of reasons arising out of changing economic patterns, some of these communities may experience a deteriorating quality of life and perhaps a decline in status and population.

13. There will likely be increased levels of social disorientation and unlawful behaviour in communities that are most strongly affected by the pipeline. The capability for dealing effectively with this kind of problem and others that the pipeline is likely to raise in the Study Region appears to be inadequate.

Main Long-Term Effects

The following may remain as the more or less permanent effects of the pipeline project following the completion of construction.

1. The Study Region will contain a higher resident population, although numbers will have fallen considerably from the peak transient-plus-permanent population attained during pipeline construction. The Lower Mackenzie/Delta Sub-region may contain proportionately more of the total regional population than is currently the case. Moreover, proportionately more people will live in larger communities.

2. There will be some change in the ethnic mixture. The proportion of non-Natives in the total regional population will increase. The Native population will continue to be numerically larger than the non-Native population only in the more slowly developing parts of the Study Region.

3. There will likely be a permanent change in occupational patterns. A higher proportion of the resident population will depend on wage employment. The traditional activities of hunting, trapping and fishing will have declined.

4. Provided that there is continued oil and gas activity, a relatively high demand for labour should be sustained well beyond pipeline construction. During the post-construction period, all members of the resident labour force willing to take wage employment should be reasonably fully employed. If full-time employment is not always available, there should be enough seasonal work to sustain wage incomes at a level that would enable people to support themselves.

5. Depending greatly on how effectively training is handled during the construction phase, there should be some enhancement of the skill levels of the regional labour force. Certainly this labour force will have become more experienced and conversant with the wage economy. Maintenance of skill levels and positive attitudes toward wage employment will depend greatly on the degree to which meaningful work opportunities continue to be available following the completion of the pipeline construction.

6. There will be an expanded regional market for goods and services. The business sector will have grown and become more efficient and diversified. There may be a trend toward substituting locally fabricated products for goods imported into the region.

7. Because of the requirements posed during pipeline construction, there will have been improvements in regional infrastructure, social services, etc. Not all such improvements or expansions of capacity will be needed during the post-construction phase, but some proportion of them will be retained and will make life in the Study Region somewhat

easier than is presently the case.

Activities Particularly Affected

Of the various private and government acitivites that have been dealt with in this report, the following could be most strongly affected by the pipeline project.

1. *Traditional activities*—hunting, trapping and fishing. The traditional economy has declined during recent decades, and the pipeline and related developments will likely accelerate this trend. Trapping may be more strongly affected than other traditional activities because its main rationale is the acquisition of cash income, which is becoming more important in the regional economy. Increasingly, cash will be more readily, and perhaps more easily, obtainable through wage employment. Hunting and fishing may continue to be important much longer than trapping, and will perhaps not diminish much below present levels.

2. *Oil and natural gas.* A favourable decision on the pipeline will accelerate exploration and developmental activity in this sector, whereas an unfavourable decision will undoubtedly retard activity for a time. Because of the very large role of oil and natural gas in the regional economy, the level of future activity in the Study Region, particularly in the Mackenzie Delta, will depend greatly on what happens within the oil and gas sector.

3. *Transportation.* This sector will have to undergo major expansion to meet the short-term requirements imposed by pipeline transport, as well as transportation needed by related activities such as gas-field development. There are dangers that a short-term situation of under-capacity could occur during pipeline construction and that, following completion of the pipeline project, the regional transport system could have redundant capacity, particularly in barge transport. Care will have to be taken to ensure that transport capacity required for normal community supply is not unduly diverted to pipeline transport during the construction phase.

4. *Communications.* The present system is already inadequate to meet all regional needs; additional capacity will be necessary to accommodate the pipeline both during the construction and operations phase. Decisions will be required on the technology to be used in such expansion and the mixture of public and private systems that would optimally serve the Applicant and the region.

5. *Construction.* While local firms can expect to participate directly in pipeline construction in only a limited way, there will be a requirement for construction services in response to activities induced by the pipeline project. There is already a substantial requirement for additional housing in the Study Region, for example. The regional construction sector will likely undergo significant expansion as a consequence of the pipeline project.

6. *Health.* A project the size of the pipeline will affect both physical and mental health in the Study Region. While the Applicant will probably take adequate care of the health needs of his employees during pipeline construction and operation, the secondary population inflows induced by the pipeline could put substantial pressure on the present medical staff and facilities of the Study Region.

7. *Social Assistance.* Again, pipeline development could have a significant impact on community, family and individual well-being, and could bring about a need to augment the present social assistance delivery system of the Study Region.

8. *Law Enforcement.* Here again the problems that will have to be dealt with could increase by some order of magnitude, putting pressure on existing regional staff and facilities.

The impact of the pipeline on other activities discussed in the Sectoral Analysis chapter of this report should be somewhat less than in the case of the foregoing. Nevertheless, there will be very few aspects of life and economic activity in the Study Region that will not be affected by the proposed pipeline in some way.

Communities Particularly Affected

Some communities will experience the impact of the proposed pipeline much more strongly than others. Proceeding from north to south, the main impact communities would seem to be the following.

1. *Inuvik.* This will be the main northern logistics and administrative centre with respect to pipeline construction and related activities such as oil and gas exploration. It will experience substantial pressures during the construction phase and could undergo rapid expansion. During the operations phase it will be one of the Applicant's three northern operating centres and this should help to stabilize the level of local activity.

2. *Fort Good Hope.* The pipeline will come within a few miles of this community, which will be used as a transit point for personnel and supplies. The community will therefore be quite directly affected by the pipeline.

3. *Norman Wells.* This will be a logistic and administrative centre during the construction phase, and, following completion of the pipeline, one of the Applicant's main operating centres.

4. *Fort Norman.* The pipeline will pass close to this community and it could therefore be directly affected by the project. Its wharf and airstrip will be heavily involved in logistic support to the pipeline.

5. *Wrigley.* The pipeline will pass fairly close to Wrigley and there could be significant interaction between the project and the community. The Applicant intends to use the community airstrip for staging purposes.

6. *Fort Simpson.* This community will be important in terms of the movement of men and materials for pipeline construction. It will also be one of the Applicant's operating centres during the post-construction phase. Change has already occurred in the community because of highway construction and other developments, and this will undoubtedly continue and accelerate with the pipeline project.

7. *Hay River.* This will be the major transshipment point for pipeline material, and the level of local activity will accelerate considerably during pipeline construction. Because of its long experience as a transportation centre, the community should be in a good position to absorb the impacts of the pipeline project, and to turn these to economic advantage.

In general, the foregoing communities are strategic to the logistics of the pipeline project or, in some cases, close to the pipeline route. One characteristic that they therefore share is that interaction of a direct physical type with the proposed pipeline is inevitable, unless the Applicant were to make significant alterations to his route location and logistic support plans. Old Crow, in the northern Yukon would be in a similar position to communities such as Fort Good Hope and Fort Norman if a decision were made to build the

Interior alternative instead of the favoured Coastal Route in connecting the prime Mackenzie Valley route with gas reserves at Prudhoe Bay, Alaska.

Communities not mentioned in the foregoing—for example, Fort Liard, Fort Franklin, Arctic Red River—will have a greater latitude of choice in terms of whether they want to become involved with the pipeline and the terms under which such involvement might occur. In some cases, interaction will take no stronger form than the employment of some local labour.

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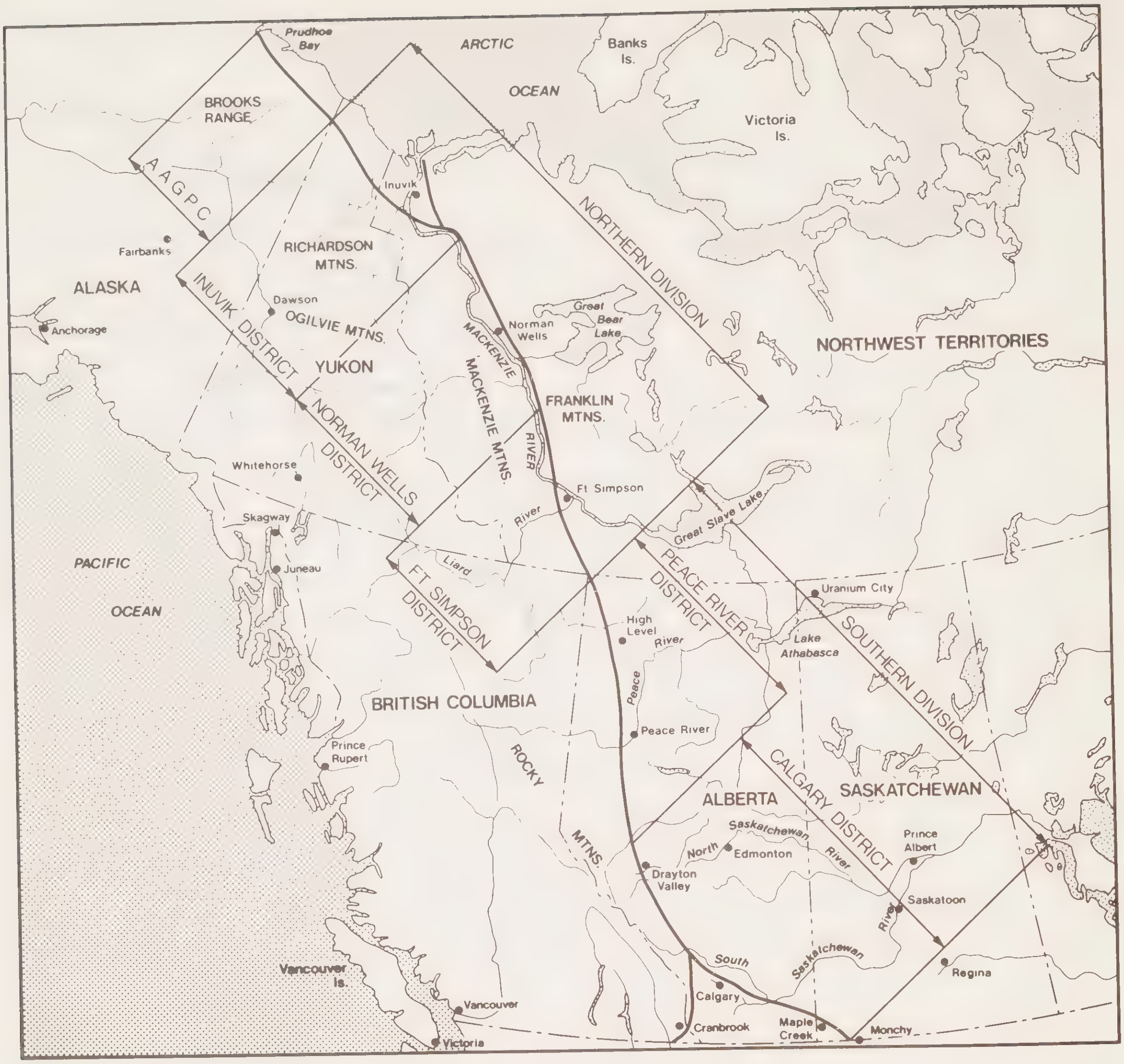
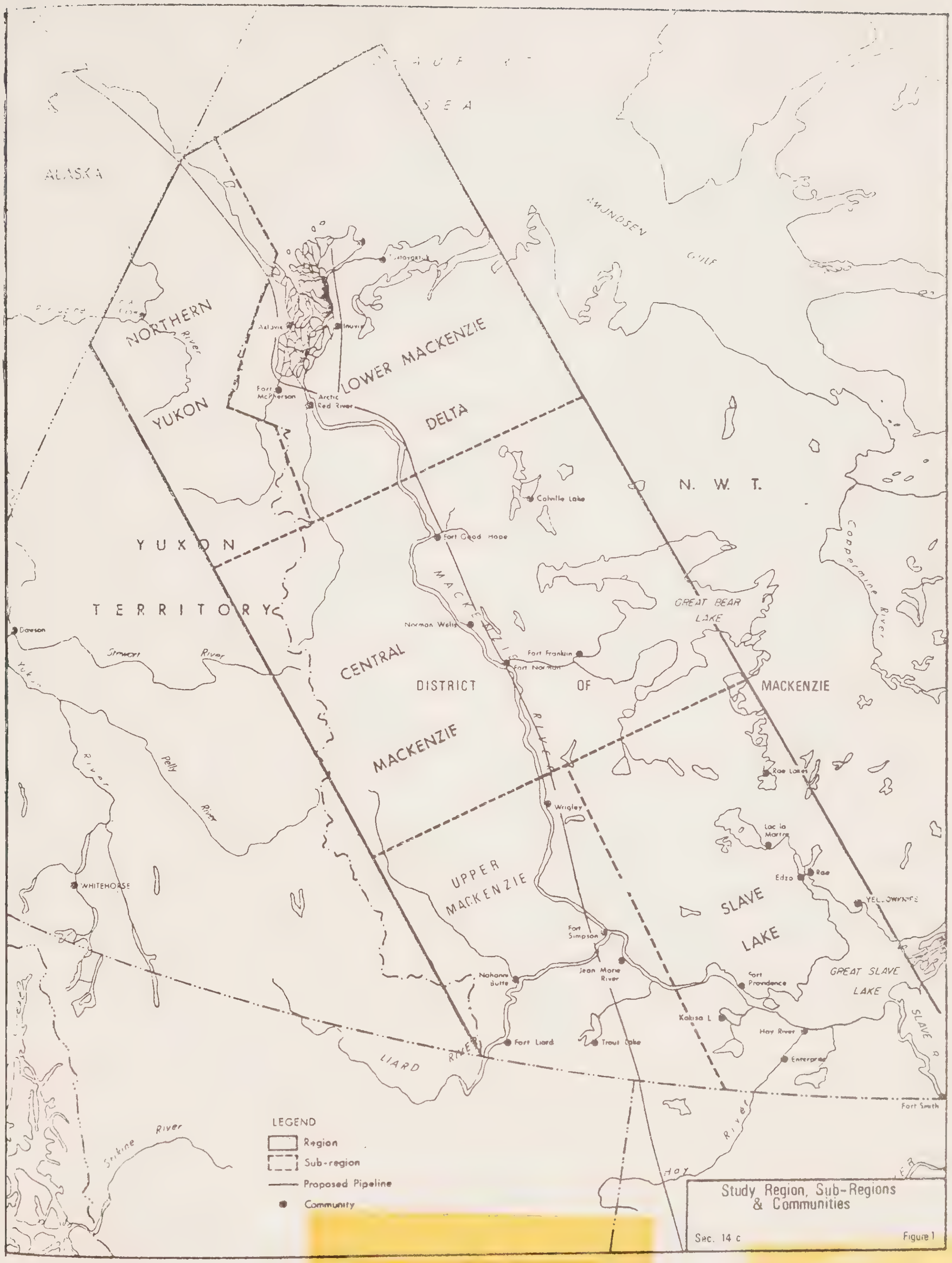
ACRONYMS

TFNOD - see #25 above.
O&GA - see #43 above.
M&MA - see #43 above.
MPS - see #28 above.
CTC - Canadian Transport Commission, Ottawa.
WCB - Workmen's Compensation Board.



Prudhoe Bay
ARCTIC
OCEAN
Banks Is.
Victoria Is.
BROOKS RANGE
AAGPC
Inuvik
Fairbanks
ALASKA
Anchorage
RICHARDSON MTNS.
Dawson
OGILVIE MTNS.
INUVIK DISTRICT
YUKON
NORTHERN DIVISION
MACKENZIE
Norman Wells
Great Bear Lake
NORTHWEST TERRITORIES
MACKENZIE MTNS.
FRANKLIN MTNS.
NORMAN WELLS DISTRICT
RIVER
Whitehorse
Ft Simpson
Skagway
Great Slave Lake
River
PACIFIC
OCEAN
Juneau
Liard
PEACE RIVER DISTRICT
Uranium City
FT SIMPSON DISTRICT
High Level
River
Lake Athabasca
SOUTHERN DIVISION
Peace
BRITISH COLUMBIA
Peace River
Prince Rupert
ROCKY
ALBERTA
CALGARY DISTRICT
SASKATCHEWAN
MTNS.
Saskatchewan
North
Edmonton
River
Prince Albert
Drayton Valley
River
Saskatoon
South
Saskatchewan
Regina
Vancouver Is.
Calgary
Vancouver
Cranbrook
Maple Creek
Monchy
Victoria

FIGURE 1


BEAUFORT SEA
ALASKA
AMUNDSEN GULF
NORTHERN YUKON
LOWER MACKENZIE DELTA
YUKON TERRITORY
N. W. T.
CENTRAL MACKENZIE
DISTRICT OF MACKENZIE
UPPER MACKENZIE
SLAVE LAKE
GREAT BEAR LAKE
GREAT SLAVE LAKE
MACKENZIE RIVER
LIARD RIVER
Stewart River
Pelly River
Yukon River
Stikine River
Hay River
Coppermine River
Slave R.
Aklavik
Inuvik
Fort McPherson
Arctic Red River
Colville Lake
Fort Good Hope
Norman Wells
Fort Franklin
Fort Norman
Wrigley
Rae Lakes
Lac la Martre
Edzo
Rae
Yellowknife
Fort Simpson
Jean Marie River
Nahanni Butte
Fort Providence
Kakisa L.
Hay River
Enterprise
Fort Liard
Trout Lake
Fort Smith
Dawson
WHITEHORSE
LEGEND
Region
Sub-region
Proposed Pipeline
Community
Study Region, Sub-Regions & Communities
Sec. 14 c
Figure 1

CHAPTER 3

GENERAL IMPACT ANALYSIS

3.1 Introduction

Many of the impacts of the proposed Mackenzie Valley Pipeline will occur broadly and pervasively and will in some way or another affect the entire population of the Study Region. Such impacts will work themselves out in many ways - social, cultural, economic and political. They could bring about a substantial transformation of northern society. Some of the main processes by which this might occur are examined in this section.

In terms of population and the level of economic development, the Northern Territories are small segments of Canadian society that are still very open to influences emanating from world markets for petroleum and metals. They are dependent on decisions, including business and political decisions, made far beyond their boundaries. The degree of uncertainty attendant on any exercise that involves predicting their future is high, and this section must be read with this in mind.

A considerable body of background material has recently been developed on the current socio-economic status of the Northern Territories and the reader requiring a more detailed treatment of various subjects than can be given here should refer to the bibliography at the end of the introduction to the socio-economic part of the report.

Topics covered in the following pages include discussion of the impact of the pipeline on population, labour force, employment, income, the private economy, communities and government. While some topics may appear to duplicate topics covered elsewhere in the report, the intent here is that of a general treatment rather than one of detail.

3.2 POPULATION

Background

The population of the Study Region has grown rapidly during the past decade, and, according to the Applicant, it stood at 23,662 by 1971. It is largely concentrated in the Slave Sub-region, which in 1971 contained about 63 per cent of the regional population (14,873 people), and in the Lower Mackenzie/Delta Sub-region which contained 23 per cent of the population (5,472 people). These Sub-regions are the location of larger urban centres such as Yellowknife, Hay River, Inuvik and Fort Smith. Of the other Sub-regions, the Upper Mackenzie comprises about 7 per cent of the Study Region population (1,602 people in 1971), the Central Mackenzie about 6 per cent (1,499 people in 1971), and the Northern Yukon only 1 per cent (216 people in 1971) (Sect. 14.c, Table 3.1).

Forecasts prepared for the Mackenzie Corridor Impact Region suggest that there will be only minor changes in the relative populations of the Sub-regions between 1971 and 1981. These projections do not take specific account of the proposed pipeline, however.

Ethnically, the population of the Study Region can be broken down into Treaty Indians, Eskimos and "Others"; the latter category includes Whites, Métis and Non-status Indians. Gemini North (1974) indicates that in 1971, total regional population consisted of 6,098 Treaty Indians (26 per cent), 1,721 Eskimos (7 per cent) and 15,883 "Others" (67 per cent). In the smaller Mackenzie Corridor Impact Region, 1971 population consisted of 3,267 Treaty Indians (37 per cent), 1,721 Eskimos (20 per cent) and 3,801 "Others" (43 per cent). Thus Treaty Indians and Eskimos comprised 33 per cent of the population of the Study Region as a whole and 57 per cent of the population of the Mackenzie Corridor Impact Region (Figures, Gemini North, 1974, Vol. VI, p.38).

Growth of the native population depends almost entirely on natural increase, which has been high during recent decades, but which has apparently been dampened in its effect by factors such as abandonment of official or special native status and migration from the Northern Territories. Growth of the "Other" population has taken place mainly by migration into the region. One source indicates that, during the 1961-71 decade, in the Northwest Territories as a whole, the Treaty Indian population grew at a rate of 1.24 per cent per year, the Eskimo population at a rate of 3.56 per cent and the "Other" population at a rate of 6.01 per cent (Forth, *et al.*, 1974, Ch. V, p.101, Figure 9). To put these rates into perspective, it would take some 56 years to double the Treaty Indian population at the foregoing growth rate, and some 20 years to double the Eskimo population, but only about 12 years to double the "Other" population.

As the foregoing growth rates would suggest, there has already been a significant erosion of the relative numerical status of the Native people in the Northern Territories. A continuation of the trend is almost certain, particularly in the Study Region. Within a decade, Native people may comprise significant, if reduced, majorities only in the less populous Central Mackenzie and Northern Yukon Sub-regions. In all other parts of the Study Region, there is little chance that their position of a declining minority within the total population will ever be reversed.

Impact of the Pipeline

Issues

The following would appear to be particularly important with regard to the topic of population:

(i) the effect of the pipeline on population growth and size;

(ii) the effect of the pipeline on the geographic distribution of population; and,

(iii) the effect of the pipeline on the ethnic mixture or balance of the regional population.

Applicant's Statement

Without a pipeline, the Applicant assumes that the population of the Study Region will grow at a rate of 3.51 per cent per annum reaching a figure of 38,374 by 1985 (Sect. 14.c.3, Table 3.1). This is in close agreement with population projections prepared within the Department of Indian Affairs and Northern Development for the Mackenzie Corridor Impact Region (Lu and Mathurin, 1973).

The Applicant does not put forward any specific estimates of the impact of the pipeline on population growth and size. His view is that the extent to which the pipeline will increase population size will depend mainly on the degree to which northern residents are able to take advantage of increased employment opportunities resulting from pipeline operation. Jobs that are not taken by northern residents will go to southern migrants, and there will be a corresponding increase in resident regional population.

Regional population will of course increase temporarily with an influx of transients during construction. However, the Applicant expects construction migrants to have little impact on the Study Region because they will be housed mainly in camps and will be kept separate from the resident population (Sect. 14.c.4.2, pp.28 and 29).

The Applicant makes no special reference to the geographic distribution or redistribution of population. However, in his "without pipeline" projections of population to 1985, he assumes that population growth among various Sub-regions will be completely proportional. In effect, this is assuming that no redistribution will take place (Sect. 14.c, Table 3.2).

There are no specific comments in the Application on changing ethnic representation, or the problems of socio-cultural identity that might arise for Native populations if their minority numerical positions should further decline.

Commentary

In its supporting study to the Application, Gemini North suggests that up to 3,000 people would migrate to the Study Region in relation to "...permanent gas industry and pipeline induced employment..." during some unspecified near-future period (Gemini North, 1974, Vol. VI, p.47, also Vol. III). Like the Applicant, Gemini argues that this number would be decreased to the extent that regional residents could take permanent pipeline jobs. Such an influx of population over an above-normal growth could create a significant high-income market which could lead to additional inflows of people such as retailers and skilled tradesmen. Any extensive publicity about "big money" being available in the Study Region could lead to further inflows of speculative transients. Many of these would be young, unattached men who could have a disturbing effect on a community. Most would probably not remain in the Study Region

for long.

Gemini North has also worked out increments to sub-regional populations that would be attributable to "...permanent gas industry and pipeline induced employment". Its "conservative" estimates suggest population increases of 268 people in the Upper Mackenzie, 230 people in the Central Mackenzie and 2,308 people in the Lower Mackenzie/Delta "by the end of the decade" (Gemini North, 1974, Vol. VI, p.47). The Lower Mackenzie/Delta Sub-region is thus likely to grow particularly rapidly during the next few years. However, population increases would be due less to the direct effects of the pipeline than to the development of gas fields and related production facilities, as well as to the boom conditions these could create. Some changes in sub-regional population distribution in favour of the Lower Mackenzie/Delta Sub-region are therefore probable.

Because of population inflows, the pipeline will undoubtedly have some effects on the proportion of the Study Region population which is Native as compared with that which is non-Native. It could also have some effect on the rate at which Native people abandon their special status and assimilate into the large society. Of consequence to the process of assimilation would be a host of factors such as the spread of wage employment, greater exposure of northern Natives to cultural influences from the South, and the growing urbanization (or "suburbanization") of the North. Examples of White society that are most frequently dealt with by Native people tend to represent middle-to-higher-income government or business officials with whom low-income Native people tend to compare unfavourably in economic status, education and technical skills. The pipeline is bound to increase the frequency with which Native people, and particularly impressionable younger people, encounter and are influenced by models of this kind.

Yet it must be recognized that changes in Native culture are already well advanced in the Study Region. The pipeline would therefore have the effect of accelerating but not fundamentally altering a process that is already underway.

Highlights

1. The pipeline project *per se* will not necessarily lead to a large increase in permanent regional population. As the Applicant points out, this would depend on the capability and willingness of northern residents to take permanent jobs on the pipeline during the operations phase. However, even if most permanent pipeline jobs are held by migrants to the region, the effect will not be particularly great in comparison with other sources of population growth.

2. The pipeline could have a larger effect on regional population growth and size through activities that it will either induce directly (e.g. Mackenzie Delta gas reservoir development) or indirectly (e.g. general business expansion in Inuvik; speculative transients) over which the Applicant may have little, if any, control.

3. Increases in regional population due to the pipeline and associated activities will be greatest in the Mackenzie/Delta Sub-region (particularly at Inuvik) and at "action" communities such as Norman Wells and Fort Simpson. These increases will occur mainly as a result of migration from southern Canada. However, there will be no major re-alignment of the present regional balance of population specifically because of the pipeline.

4. Native people are becoming a minority in the Study Region and this trend is likely to continue with or without the pipeline.

3.3 LABOUR FORCE

Background

Reflecting population growth, the labour force of the Study Region has grown rapidly during recent decades. Estimates made by the Applicant for 1971 indicate a population of 13,549 of labour-force age, that is, between 15 and 64 years of age. This is 56 per cent of the estimated total population, a somewhat higher proportion than would typically occur in Canada as a whole. About 56 per cent of this population is male (Sect. 14.c, Table 3.5). Persons between the ages of 25 and 34 comprised the largest single age class within the working-age population (TFNOD, p.206).

Probably reflecting migration to the Northern Territories more than inter-community movement within the Study Region, the more economically active and populous Sub-regions tend to have a higher proportion of people of labour-force age within their total population than is the case with less active Sub-regions.

The Applicant's data indicate that in the economically active Slave Sub-region, the 1971 population of 8,767 persons of labour-force age comprised 59 per cent of total Sub-regional population. The Lower Mackenzie/Delta Sub-region population of labour-force age appears to have comprised 53 per cent of the total population. In comparison, the Applicant's data indicate that working-age population comprised only 50 per cent of total population in the Central Mackenzie and only 48 per cent in the Northern Yukon (Sect. 14.c, Tables 3.2 and 3.3).

The labour force of the Study Region is far from homogeneous due to factors such as the varied cultural background of the population and large variations in experience with wage employment. Most migrants from southern Canada depend on wage or salary employment. Among Native groups, Métis members of the labour force have a history of more active participation in wage employment than do Treaty Indians or Eskimos. The economic attitudes and values of all Native people, however, still tend to relate to a more traditional, less market-oriented economy than the one that has now become dominant within the region. Nevertheless, all Native groups now derive most of their income from working for wages, even though much of the work they undertake is of a seasonal nature.

By way of illustration, a survey undertaken in 1969 and 1970 revealed that 80 per cent of the total cash income of Native residents of the Lower Mackenzie/Delta Sub-region derived from wage employment, whereas only 17 per cent came from hunting, trapping and fishing. In the Central and Upper Mackenzie Sub-regions income from wages was a lower proportion of earned income, but was still well over half of all cash earnings. This survey further indicates that, in the whole of the Mackenzie Corridor Impact Region, just under 40 per cent of the Native labour force is wage employed more or less permanently, whereas only about 10 to 15 per cent is employed in hunting, trapping and fishing (Northern Manpower Survey Program, 1969-1971, Statistical Tabulations).

One factor which may account for some of the inequalities in the distribution of cash income among Native people is the degree to which they pursue wage employment relative to trapping, the main source of such income in the "traditional" economy. In terms of effort expended, cash returns from wage employment are typically much higher than returns from trapping, and the aware-

ness of this has drawn many Native people into at least part-time wage work.

Members of the labour force who have moved to the Study Region from the provinces are typically well trained and educated and may perhaps exceed Canadian standards in this respect. In contrast, Native workers generally have few marketable skills and little job experience and are relatively immobile in labour market terms. Skill levels nevertheless have been rising as has contact with and experience in wage employment during the past decade. Nevertheless, a relatively high proportion of the Native people of the Northwest Territories have never attended school, and very few have gone into increasingly necessary post-secondary training. Clearly, northern Native people do not comprise a labour force that can easily compete with migrant labour from the Canadian south.

Involvement of Native people in the wage economy appears to have led to some loss of the skills and knowledge needed in the "traditional" economy. Generally, only older Native men now know how to hunt and trap effectively; these skills typically are not possessed by younger persons who have often had little experience of the land. Indeed, many young Native people appear to be caught somewhere between the "traditional" and the modern economies, not having the training that is needed to be fully involved in either.

Impact of the Pipeline

Issues

The following issues appear to be particularly important with respect to the regional labour force:

(i) the effect of the pipeline on over-all labour-supply parameters, such as size and participation;

(ii) the effect of the pipeline on the quality of the regional labour force;

(iii) the effect of the pipeline in decreasing the Native labour force involved in "traditional" activities (hunting, trapping and fishing) and increasing the proportion involved in wage employment.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references to these issues—particularly the second issue (Guideline 1)—and this has raised questions contained in "Requests for Supplementary Information".

Applicant's Statement

The Applicant makes little specific reference to the impact of the pipeline on total labour-force size and participation. Instead he devotes considerable effort to estimating the size of the male population aged 15 to 29 years, perhaps because these are the people that he is most interested in hiring (Sect. 14.c, Tables 3.7 and 4.9).

The Applicant states that he will train northern residents for employment on the pipeline, but that he will not attempt to correct any inadequacies in the formal education of the Study Region. A training program, established by the Applicant and aimed at permanent employment during the operations phase, has been in effect since 1971. In 1973, seventy-three training positions were made available by sponsoring companies and all of these were filled. In 1974, these positions were to have been expanded to number about 120 and further increases are planned. The Applicant says that the development of this training program has had, and will continue to involve, the cooperation and partici-

pation of the Governments of Canada, the Yukon Territory and the Northwest Territories (Sect. 14. c.5.2.1, p.35). He also states that companies that sponsored training positions have made a major commitment to the program. This includes provision for further upgrading for employment after candidates have successfully completed training.

The Applicant intends to provide a variety of less intensive training programs during both pipeline construction and operation. These will be aimed mainly at Native Northerners and would include general social orientation for families and on-the-job training and upgrading courses for employees. Employees from southern Canada, particularly supervisors, will receive instruction on the social and environmental characteristics of the Study Region. Training will be continuous and will persist throughout the project (Sect. 14.c.5.2.2, p.36).

Commentary

The boom conditions that may prevail in the Study Region during pipeline construction could create a situation of high labour demand and, within certain limits, of rapidly rising wages. Native participation in wage employment therefore should increase, at least to the extent that current low participation reflects a scarcity of attractive wage employment opportunities. Certainly, any Native person who possesses skills or education beyond the ordinary should be in a good bargaining position in the regional labour market.

People who would not normally be in the labour force may be induced into employment roles for a time. Married women and older people could perhaps fill in for men who had been drawn into employment on the pipeline. A negative effect in this regard could be that younger people will be attracted by the wages offered on the pipeline instead of completing academic and vocational studies which could make the northern labour force more competitive in the long term.

Eventually, given present trends, participation by the Native labour force in wage employment could become virtually complete, and the pipeline could hasten this. The Government of Canada, in keeping with announced policies, is likely to influence strongly all employers associated with the proposed pipeline to hire Native people. It would seem that the Applicant is interested in employing as many Native people as possible, especially during the operations phase of the pipeline, when long-term permanent employment will be made available. Given the small size of the resident labour force of the Study Region, it would not take many employers like the Applicant to absorb most Native members of the regional labour force who are willing to take wage employment.

With respect to the quality of the northern labour force, the training programs to which the Applicant has committed himself should have the effect of permanently enhancing the Study Region's stock of "human capital" provided that, after the pipeline is built, there is a continuing opportunity for people to use the skills and experience they will have acquired. Native people are expected to learn new techniques, broaden their awareness of the labour market, become more mobile, enter supervisory and trades roles, and, on the whole, become better able to deal with the growing wage economy.

Yet a great deal depends upon the knowledge and sensitivity with which training and educational programs are administered. Native people in many situations have proven themselves to be hard and dedicated workers, often outperforming more experienced non-Native members of the labour force.

Highlights

1. Construction of the pipeline will increase the size of the available resident labour force of the Study Region through the creation of a substantial number of employment opportunities. This increase will result mainly from greater participation by Native people, whose participation is currently low, perhaps because of limited employment opportunities.

2. The pipeline development should considerably enhance the quality of the resident labour force of the Study Region. Moreover, the quality may well be maintained if a high rate of employment prevails after construction of the pipeline has been completed.

3. Given the economic and social forces presently at work in the Study Region, it is likely that fewer and fewer Native people will continue to derive their livelihood from hunting, trapping and fishing. The pipeline project and related events should have the effect of accelerating the redistribution of labour from the "traditional" to the wage economy.

3.4 WAGE EMPLOYMENT

Background

The impetus for recent economic growth in the Study Region has come mainly from sources such as oil and gas exploration, construction programs in communities, and the development of transportation infrastructure. While many of the jobs that have arisen out of this have been seasonal or casual and have tended to be concentrated in certain localities, there has been no real scarcity of employment opportunities during the past few years. It has become increasingly clear that if residents of the region do not take wage employment of some form during the year, it is because they prefer not to, and not because jobs are unavailable.

Even without the pipeline, these trends should continue, so that by 1985 much of the labour force willing and able to work could be wage employed. This would be especially likely if developments such as the Athabasca Tar Sands and petroleum exploration in the Beaufort Sea, each of which will require a substantial labour force, proceed more or less on schedule in regions that are contiguous to the Study Region.

Impact of the Pipeline

Issues

The following appear to be particularly important with regard to the subject of employment:

(i) the effect of the pipeline on the total employment of the regional labour force;

(ii) the kinds of jobs that will be available to this labour force;

(iii) the competitive position of the regional labour force *vis-à-vis* transient labour from southern Canada.

The "Social Guidelines" section of "Expanded Guidelines for Northern Pipelines" contains references to various aspects of these issues (Guidelines 1 and 2) that have provided the basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant uses employment benefits as a proxy for total regional benefits, emphasizing employment created not only by pipeline construction and operation, but also by closely related activities such as the development of Mackenzie Delta gas reserves. Three types of employment are distinguished in the Application. Primary Direct employment refers to activities involved in the construction and operation of the pipeline. Primary Indirect employment refers to activities related to the pipeline or actually supporting pipeline construction and operation, for example, jobs in gas exploration, development and production, in transportation and in equipment supply. Secondary employment refers to jobs created in the service and other sectors of the economy as a consequence of increased spending within the region by people holding Primary Direct and Indirect jobs.

Excluded from these categories are some types of employment. For example, the Applicant does not predict the employment effects of expenditures on casual labour or on local contractors during the operations phase even though he indicates that these effects may be of some consequence. Also, he does not predict job formation resulting from general population growth not induced by the pipeline which should follow from the increasing

industrial activity in the region.

Job formation visualized by the Applicant would be substantial. Primary Direct, Indirect, and Secondary employment would generate a total of 1,887 man-years in 1975 and a total of 6,308 man-years by 1978. By 1981, employment would have dropped back to 3,394 man-years, and by 1982 this would have fallen further to 1,956 man-years. However, by 1982 an additional 1,000 man-years would have become available through further gas-field development and expansion in the Study Region (Sect. 14.c, p.26, and Table 4.7).

Skill levels required on the pipeline will be high. Referring to Primary Direct pipeline employment only, the Applicant states that in 1975, 49 per cent of the man-years he will require will have to be filled by skilled labour and an additional 22 per cent by semi-skilled labour. By 1977, 62 per cent of the pipeline labour force will have to be skilled and an additional 18 per cent will have to be semi-skilled. As the operation phase is approached proportions that are skilled will become even higher. Thus in 1981, it is anticipated that 71 per cent of the pipeline labour force will have to be skilled and an additional 14 per cent semi-skilled, leaving only relatively small allowance for unskilled labour (Sect. 14.c, Tables 4.1, 4.3).

The major source of Primary Indirect employment is expected to be the Mackenzie Delta gas development and production, which could in fact be the largest single source of any type of employment mentioned by the Applicant. This is followed by petroleum exploration which should perhaps be viewed as less directly related to the pipeline. Much further down the list are other Primary Indirect activities—water transport, rail transport, and equipment storage and supply.

Concerning the derivation of Secondary employment, the Applicant indicates that he used an income multiplier of 1.2 which was selected after "A review of a number of regional impact studies for other regions—Alaska for example—..." (Sect. 14.c.4.1.3, p.25). He chooses not to apply this multiplier to estimates of construction-phase Primary Direct employment because he believes that transient workers will not spend much money in the Mackenzie Region. Yet he indicates significant man-years of Secondary employment during this period without saying how these were derived. Only in 1982 and in following years, that is, after the pipeline has become operational, does the Applicant use his multiplier to derive Secondary employment estimates. For these years, Secondary employment is exactly 1.2 times the sum of Primary Direct and Indirect employment.

Primary Indirect employment should, according to the Applicant, be a much more significant source of jobs than either the Primary Direct or the Secondary categories. Also, it will not exhibit the extreme peakedness associated with Primary Direct employment. Of the total number of 38,414 man-years of employment that the pipeline is expected to generate during the 1975-1985 period, Primary Indirect employment should account for 22,551 man-years, or about 59 per cent. The development and production of gas reserves in the Mackenzie Delta alone will generate 31 per cent of all man-years of employment created by the pipeline during the 1975-1985 period (Sect. 14.c, Table 4.5). Primary Direct employment—that is, construction and operation of the pipeline—is expected to provide only 10,999 man-years of employment or 29 per cent of all jobs. Secondary employment runs considerably behind the other categories, generating only 4,864 man-years, or 15 per cent (Sect. 14.c, Table 4.7).

The Applicant's estimates should be viewed as

being relevant only to the demand side of the labour market. Whether the potential employment they indicate can actually be achieved will depend very much on whether adequate supplies of local, regional and "outside" labour will be forthcoming. The Applicant says very little about potential labour supply problems he may encounter.

The Applicant uses two techniques to demonstrate the over-all effect of pipeline-generated employment. With one of these, he shows that such employment could equal 30 to 100 per cent, depending on the year, of all jobs available in the Study Region during 1972 (Sect. 14.c, Table 4.8). With the other technique, he shows that, for peak construction years, the pipeline could more than absorb the Study Region's 15- to 29-year-old male labour force. During non-peak years, it would at no time absorb less than 40 per cent of this age group (Sect. 14.c, Table 4.3).

With respect to the quality of the regional labour force the Applicant says that, although he does not propose to become involved in correcting inadequacies in the formal education of people in the Study Region, those who continue in school should find it easier to obtain employment. Education and training should therefore become more attractive to young people. The Applicant thus feels that the pipeline can be expected to have a longer term positive effect on educational attainment in the Study Region.

Such longer term considerations aside, the Applicant recognizes that Native people will have difficulties in competing for available jobs on the pipeline with persons who have had much more experience in industrial wage employment and who would therefore have "an immense advantage" in such competition. He is aware that corporate hiring policies will have to compensate for prevailing inequalities, but suggests that preferential hiring would mean little if Native people were merely relegated to unskilled and semi-skilled positions. Disparities in the treatment of Southerners and Northerners on the job, or with respect to job access, could lead to tensions among ethnic groups. It is this kind of thinking that has led the Applicant to establish his northern training program (Sect. 14.c, pp.29, 34, 35).

Commentary

If a considerable proportion of the Study Region labour force were already fully occupied or employed, the regional impact of the pipeline construction could be much less than the Applicant suggests. The main effect of the pipeline might then be to induce a substantial in-migration of transient construction labour. A considerable influx of such labour is probably inevitable in any event because the regional labour force would not likely be capable of meeting more than a small part of the requirements that the pipeline and associated projects will generate.

Employment on the pipeline will exhibit extreme seasonal peakedness because construction will involve the amassing of large numbers of people in a short period of time, keeping these people together during the winter construction season, and then rapidly disbanding and moving them to a southern location as warmer weather approaches. Superimposed on such seasonal trends would be constant comings and goings due to crew rotations.

Because of the extreme haste with which construction will have to proceed if it is to take full advantage of the winter season, local people will likely be assembled into crews very rapidly. Unless a great deal of attention is given to hiring, substantial chaos and confusion could result.

Conflicts could arise between the need to meet construction schedules and the needs of communities for enough manpower to perform certain basic tasks.

Under circumstances of reasonably full employment, a high demand for labour during construction could lead to significant wage increases in the Study Region. This would result from competitive bidding for labour by pipeline contractors and other employers and could be aggravated by general labour shortages which would transcend purely local and regional shortages. With projects such as the proposed pipeline, the Mackenzie Highway, Mackenzie Delta gas development, Beaufort Sea petroleum exploration, the development of the North Slope oil and the Athabasca Tar Sands all proceeding simultaneously, labour could become quite scarce throughout northwestern North America.

This could have a negative impact on the viability of small local business enterprises within the Study Region. Through creating pressures on wages, it could raise costs and, given some limitation to their ability to adjust prices, it could create some problems for small firms. It could also affect labour force participation, bringing into the labour force persons who would not normally participate, for example, married women and older men.

If the situation in the Study Region were one of widespread unemployment, construction of the pipeline could have a beneficial and stimulative effect. There would still have to be safeguards, however, to ensure that regional residents, particularly Native people, were being placed in legitimate employment roles, and were not merely being made the object of make-work programs. In the past, such programs, many of which have failed, have been a major source of the cynicism with which disadvantaged groups tend to view government efforts to put them to work.

The Applicant has indicated an interest in placing northern residents into meaningful employment roles during the operations phase, and recognizes many of the problems that could arise out of providing them with employment during construction. It is likely that only a limited number of Native people will be able to participate in other than unskilled employment during construction. The time remaining to prepare them for higher paying jobs is simply too short, if present scheduling is adhered to.

The proposed pipeline could have a positive longer run effect on the competitive position of the northern labour force. It could result in more capable and experienced workers, with Native people participating in the operation of the pipeline, and perhaps also in the construction of additional lines in the Mackenzie Valley and elsewhere. Yet changes in the labour-market status of Native people will require not only an enhancement of their skills, experience and mobility, but also the breaking down of negative and damaging attitudes that many employers still hold toward them. To be successful, a program of meaningful employment for Native people may squarely have to meet some deep-seated prejudices.

Government must ensure that the cooperation of both management and labour is attained in any programs dealing with the employment of Native people on the pipeline or in related activities. Having the good will of only one side is not enough because when things get difficult good intentions can rapidly fall away and blame can always be attributed to the uncooperative attitude of the other side. Moreover, unions have their own corporate interests which they may not view as being served by allowing

a substantial group of non-members access to jobs.

Highlights

1. The pipeline and related projects will generate a substantial number of employment opportunities in the Study Region during the construction phase. The largest group of these will not relate directly to the construction of the line, but rather to the development of the gas production facilities that will feed into it.

2. Whether or not these opportunities will have a significant impact on employment of the resident labour force will depend on the general state of labour demand prevailing in the Study Region at the time of pipeline and related construction. If, as seems likely, the demand for labour will already be high, the employment impact on people living in the region could be quite small. Under such circumstances, a principal result of the pipeline could be the in-migration of a substantial labour force to supplement that of the region. If, on the other hand, there is substantial unemployment as pipeline construction gets started, the employment effect on people in the region could be highly beneficial.

3. Skill requirements on the pipeline, and in jobs in related industries, will be quite high. It is not probable that the northern labour force, particularly Native people, will be able to meet the requirements of more than semi-skilled and unskilled jobs during construction. During operation, however, Native people should increasingly be able to take on skilled employment roles, provided that current and planned training programs have the desired effect.

4. Because of its sheer size and "peaky" character, employment on the pipeline could, unless carefully organized, appear to be chaotic and confusing from the local level. It could deprive small communities of vital labour and place small businesses in jeopardy if they were required to match pipeline wages to hold their employees.

3.5 WAGE AND SALARY INCOME

Background

With the growth of private activity and the expansion of government services, the total value of wage and salary income in the Northern Territories has grown rapidly during recent years. One study indicates that, for the Northwest Territories, wage and salary income rose from an estimated $57.9 million in fiscal year 1967-68 to $97.7 million in 1970-71; for the Yukon Territory they rose from an estimated $39.4 million to $59.5 million during the same period. Thus, not taking the effects of inflation into account, total annual wage and salary income increased at a rate of close to 20 per cent in the Northwest Territories and nearly 15 per cent in the Yukon Territory (Palmer, 1974, Appx. 2, pp. 116-119).

While consistent series have not been developed for years subsequent to 1970-71, it is believed that the foregoing trends have continued. In both territories, the rise of both total and average per capita income was more rapid than for Canada as a whole. Much of this income growth focuses on the Study Region, where the acceleration of activity has been particularly rapid because of events such as northern oil development, the growth of government administration and the Mackenzie Highway.

Almost nothing is known about the multiplier effects of wage and salary payments in the Study Region. It is suspected that these effects are still relatively slight, and that payments received by local residents quickly tend to find their way out of the region. However, this may be changing in centres such as Yellowknife and Inuvik whose economies are becoming increasingly diversified.

The fact that total wage and salary income has been rising does not mean that the region's problems with respect to income have been resolved. A highly unequal distribution of income—the inequalities coinciding with basic ethnic divisions—is one of the most evident of current facts about the Study Region. Recent data (1969 and 1970) indicate that the average annual family income of Whites in the Mackenzie District was $9,748; of Métis, $5,136; of Eskimos, $4,643; and of Indians, a mere $2,568. Moreover, a much greater proportion of Native families had incomes lower than their group average than was the case with White families (Kuo, 1972, pp.6-7).

On a community basis, those associated with developmental activities or which function as centres of resource production and government administration, tended to exhibit high average income levels. Leading communities in terms of average annual family income (1969 and 1970) were Norman Wells ($10,744), Yellowknife ($9,626), Pine Point ($8,633), Inuvik ($8,529), Hay River ($7,747), and Fort Smith ($7,201). On the other hand, small and/or isolated Indian communities had the lowest income. In settlements such as Jean Marie River, Yellowknife Village and Snowdrift, annual cash income per family was less than $1,800. This was also true of Fort Resolution, despite its proximity to a major mine at Pine Point (Kuo, 1972, Appx. G, p.30).

While such differences of income reflect differences in group well-being in the Mackenzie Valley, they also may indicate that important cultural differences still exist there. In several small communities, the fact that money income is low may indicate a relatively small need for cash rather than evidence of poverty. Such communities are still largely attuned to a subsistence economy in which people look after their own needs by

hunting and fishing. Income in kind, which was not included in the foregoing figures, represents an important part of total income, and often there is little knowledge of how to handle more than small amounts of cash.

Impact of the Pipeline

Issues

The following are particularly important relative to wage and salary income:

(i) the effect of the pipeline on the size of total wage and salary income;

(ii) the effect of the pipeline on differences of income among the main ethnic groups and within the population of the Study Region as a whole.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" indicates that residents of the territories shall not be treated differently from other pipeline workers with respect to benefits and allowances included in collective agreements between the Applicant and organized labour (Guideline 3). It is assumed that the corollary of "equal pay for equal work" also applies even though it is not specifically stated.

Applicant's Statement

The Applicant uses employment as a proxy for the regional income effects of the pipeline and makes little reference to wage and salary payments. About the only significant statement he makes about regional income *per se* is that he expects it to increase over time as training programs result in more northern residents taking on higher paying positions with the pipeline during the operation phase (Sect. 14.c, 4.c, p.29).

Commentary

The economy of the Study Region often has been depicted as one of unemployment and underemployment. This is only partly the case and in fact it is becoming less so all the time. Moreover, the demand for labour is increasing. Public and private investment in the region should ensure that most of the employable labour force will be absorbed during the latter 1970's and the 1980's even without the proposed pipeline. Demand for labour within the Mackenzie Valley could be bolstered by events immediately outside the region such as Beaufort Sea petroleum exploration and the development of the Athabasca Tar Sands and the Alaskan North Slope. It is probable, therefore, that many of the jobs that the Applicant attributes to the pipeline will have to be offered to transient workers who would be relatively isolated from contact with the regional economy. If this proves to be the case, then the impact of the pipeline on aggregate regional income could be relatively moderate.

The TFNOD Report projects total skilled and semi-skilled (or experienced) labour resident in both territories during certain typical years of pipeline construction and operation; the figure for 1977 for example, is 1,152 persons. It then estimates how many of these people could actually be employed directly on the pipeline during each typical year, and calculates regional increments in salaries and wages that would accrue over and above earnings in the occupations these people would likely follow if there were no pipeline, assuming that they were fully employed (TFNOD, Sect. F.3.3 to F.3.5).

The wage bills derived are $5,344,791 (1977), $2,988,394 (1980); and $950,873 (1983). To put

them into some kind of perspective, these work out, respectively, to 8, 4, and 1 per cent of total salaries and wages accruing to residents of the Northwest Territories during 1970. By the end of the 1970's, regional wage and salary income should have risen to perhaps twice the 1970 level, and the importance of pipeline salary and wage payments will have become reduced accordingly. However, the TFNOD estimates refer only to direct employment on the pipeline and do not take into accound employment in activities either functionally related to the pipeline or dependent on the pipeline via some type of multiplier.

Nevertheless, the figures are based on the assumption that the total territorial supply of skilled and semi-skilled labour would be available to pipeline construction. During the peak construction year, which is assumed to be 1977, the TFNOD analysis suggests that there would not even be sufficient skilled and semi-skilled labour left over to participate in indirect and secondary activities related to the pipeline. All such labour would have to be imported into the region. This points to a fundamental issue that seems likely to dominate employment in the Mackenzie Valley during the coming decade, a shortage of resident labour. The number of local people that could be employed by a project such as the pipeline, and hence the salaries and wages that might be paid out to regional residents, may be quite limited.

Of course, with labour supply so inflexible, higher than average wages and salaries likely would be earned by territorial residents. Undoubtedly these would be somewhat higher than otherwise; their level, however, depends on processes such as collective bargaining and on market forces, which would tend to ensure that they would not be too far above national levels. Employers might become reluctant to pay local labour high wages if more senior and experienced labour were available in the south. Trade unions, whose focus tends to be national or at least regional, would be concerned that seniority lists should be observed and that high-paying jobs should go to long-term members, wherever they lived. Also, a whole set of cultural factors could complicate wage and income determination insofar as Native people are concerned. There is some possibility that many of these people would work towards the attainment of some minimal level of income during a relatively brief period rather than attempting to maximize the income they receive by staying on the job for the entire annual construction season.

Because so much of the labour employed in the Northwest Territories during the next decade likely will be transient, the multiplier effects of wage payments probably will be quite low. In some cases, money may not even enter the territories. Deposits may simply be made to a worker's account wherever he is domiciled. The Applicant's proposed policy of isolating camps from communities could mean that virtually no money transactions need pass between transient construction workers and a local economy.

At this early stage only a few general observations are possible regarding the effect of the pipeline on the distribution of income in the Study Region. Many people will make a little money from the pipeline, and some may even make a great deal. Yet, once the pipeline has been completed and the regional economy settles down to a more normal level of activity, it is unlikely that present inter-ethnic distributional patterns will have been altered greatly. Even though most people may be better off materially, the economically dominant White group should still, on the average, be better off than the Native groups. Not even a project of the magnitude of the pipeline can greatly change the forces that have shaped the structure

of a society for many decades.

Some Native people will undoubtedly be much better off than they would have been if the pipeline had not been built, particularly those that are able to get permanent employment with the pipeline or associated activities. Others, who would be unable to adapt to the rapidly changing social environment, likely would be worse off. Probably, fewer Native people will be involved in their traditional pursuits of hunting, trapping and fishing than is now the case.

Judging from what is happening on the Alaskan North Slope, some very high individual wage and salary incomes could result from the pipeline. However, only in a relatively few cases would these go to regional residents. In most cases, they will go to highly skilled transient workers and tradespeople who are in short supply industry-wide (Globe and Mail, October 15, 1974, p.B.4).

Highlights

1. The pipeline project will increase total wage and salary incomes of residents of the Study Region. However, this effect could be reduced considerably if, as seems likely, people who normally would be available for pipeline employment already are employed due to a relatively high regional demand for labour.

2. Another dampening effect could result from the fact that some portion of the Native labour force may want to work on the pipeline only on a casual basis. Some Native people may not wish to work on the project at all.

3. If transients are separated from close contact with the regional economy, as the Applicant intends, the fact that they draw high wages should have little impact on the regional economy.

4. While many regional residents may become better off because of the pipeline, particularly if post-pipeline employment is somehow sustained at a high level, present income distribution patterns are not expected to be greatly affected by the project.

5. The highest wages and salaries resulting from the pipeline project likely will accrue to highly skilled transient workers and not to regional residents.

3.6 COST OF LIVING

Background

The Study Region is an expensive place in which to live. Compared with Edmonton, retail prices and living costs are 20 to 30 per cent higher at Yellowknife and Fort Simpson, 30 to 40 per cent higher at Inuvik and Aklavik, and 40 to 50 per cent higher at Tuktoyaktuk and Fort McPherson ("Comparative Living Costs" Survey, Statistics Canada, 1974). In general, these higher price levels reflect the diseconomies of seasonal shipment of goods, prolonged storage, small volumes and limited choice of outlets.

Housing costs in the territories are also significantly above those in the provinces. In some communities, particularly those that have experienced rapid growth, shortages of serviced land have become acute, adding significantly to accomodation problems.

The higher prices and costs that prevail in the Study Region are experienced differently by various communities and groups. Larger and more economically active communities, which are required to accommodate a substantial transient population, are more prone to pressures on housing, hotel space and serviced land on which facilities such as trailer camps can be established. In smaller communities, higher costs stem more directly from factors such as isolation and difficulty of access.

Whether or not a large merchandising company such as the Hudson's Bay Company is present in a particular community could make a difference to local prices. The presence of a consumers cooperative could also have a downward effect on the prices of foods and dry goods.

People who are permanently employed in the Study Region or who work there briefly as transients, are not unduly affected by high or rapidly escalating prices because their salaries and fringe benefits are sufficient to enable them to maintain a relatively high standard of living. This is not the case with many other people, and perhaps even most people. Persons who must live on fixed low incomes in the Study Region, mainly Native people, feel the impact of high prices with particular severity.

Impact of Pipeline

Issues

The following would appear to be particularly relevant to the topic:

(i) the effect of a pipeline-induced influx of population on the price and availability of accommodation, foodstuffs and other goods and services;

(ii) the burden of this effect on various groups and communities.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contain references to these issues (Guideline 7) and have provided a basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant says little about the effect of the pipeline on prices or the cost of living in the Study Region. Some problems with respect to housing are recognized, but he believes that he will not aggravate these, stating that it is his policy not to do so. He further states that his activities

will lead to an increase in the capacity of the construction industry. This, as well as rising income levels, should have a favourable effect on the adequacy of housing in the long term (Sect. 14. c, p.29).

Commentary

It is probable that pipeline construction will lead to an influx of population to the Study Region in addition to the labour force that the Applicant and his contractors will house in camps. Depending on location, moderate to severe shortages of housing, materials, and transportation could be experienced along with a general increase in prices. It is unlikely that the small capacity of the regional trades, service and retailing industries could accommodate activity of the magnitude of the pipeline without being extended to their limits. Some considerable industrial and commercial expansion could take place in anticipation of the pipeline but businessmen would be reluctant to undertake investment until the pipeline was a certainty. They would not want to risk excess capacity if the pipeline did not go ahead, or if their commercial possibilities were short-lived.

As is already the case, low-income families would be particularly affected by shortages and rising prices. They could perhaps avoid some aspects of the rising regional cost of living by maintaining their homes in smaller communities and by increasingly supplementing cash income with income in kind. However, hunting could be difficult to pursue where heads of families spend considerable time working on the pipeline. Also, game may become scarce in accessible areas during pipeline construction.

In the long term, the pipeline could play a role in bringing regional prices into closer alignment with national prices. In general, this would come about in the manner that the Applicant has suggested with respect to housing. On the supply side, there should be an expansion of the regional capacity to deliver all goods and services. Perhaps this could include some local production of goods now imported into the region, but of greater consequence might be improvements in transportation, including a reduction in the effects of seasonal factors. The costs of goods and services available in the Study Region therefore could fall somewhat. On the demand side, growth of population and per capita income should lead to an expanded market. This would permit increased commercial diversification (a broader choice of goods and services available locally), more competition and the greater applicability of the economies of scale. In combination, supply and demand factors could have a downward effect on the regional cost of living.

Highlights

1. During pipeline construction, population flows and activities induced by the pipeline are likely to raise the cost of living and create shortages of goods and services in Study Region communities.

2. Rising costs and shortages are likely to fall with particular severity on low-income Native groups whose incomes cannot be readily adjusted upwards.

3. Rising costs and shortages will be experienced most strongly at "action" communities such as Inuvik and Fort Simpson.

4. In the long run, the pipeline could serve to bring about a closer alignment of regional and national prices.

3.7 PRIVATE ECONOMY

Background

The private economy of the Study Region is characterized by smallness of scale, lack of diversification and high costs. It consists of a series of sub-markets that are separated from major supply sources and from each other by considerable distances, and linked largely by seasonal transportation. Individual sub-markets are small and permit few economies of scale. There is some manufacturing but this is only poorly competitive with products imported to the region. There are significant "non-market" and barter elements. Many people still provide food for their own use by hunting and fishing and there is considerable sharing of fish and game.

In the absence of a natural gas pipeline, or another development of similar purpose and scale, it is possible to foresee only gradual growth and diversification of private activity based mainly on export-oriented industries such as mining, tourism and traditional fur harvesting, and perhaps some continued oil and gas exploration. Of these activities, mining, which is now concentrated in the southerly part of the Study Region, likely would continue to be the leading industry. Eventually, tourism based on the unique scenic wealth of the region, would take on more significance. Without the kind of government encouragement that is available to other primary industries, traditional fur harvesting probably would continue to decline.

Impact of the Pipeline

Issues

The following are of particular relevence to the topic:

(i) the effect of the pipeline on the local and regional market for goods and services and hence on the growth and diversification of the business firms that cater to this market;

(ii) the effect of the pipeline on the export-oriented major resources industries of the Study Region.

The "Social Guidelines" of the "Expanded Guidelines for Northern Pipelines" contain references to various aspects of these issues (Guidelines 4 and 7) and these have prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant intends to purchase materials, supplies and services from firms in the Study Region. He states, however, that he must balance the maximizing of regional economic benefits with ensuring the prompt and timely delivery of supplies and materials.

The Applicant indicates that care should be taken to avoid building up unjustified expectations that could lead to excess capacity within the Study Region. He warns that problems could arise owing to pipeline construction being geographically mobile and seasonally variable (Sect. 14.c, p.37). He recommends that "a mechanism" be established to inform regional entrepreneurs about goods and services that they may be able to provide to the Applicant or his sub-contractors. This would help to keep regional expectations and investment within bounds (Sect. 14.c, p.40).

In terms of the development of major resources, while he briefly discusses activities such as forestry, commercial fishing and mining, the

Applicant's main concern is with the effects of the pipeline on the petroleum industry. He points out that while estimates of proven hydrocarbon reserves are not published, there is wide acceptance in the petroleum industry that potential reserves in the Study Region are probably greater than all currently proven reserves in Canada. It is the Applicant's view that, in the absence of the pipeline, oil and gas exploration would decline and predicted regional employment and other benefits would not materialize (Sect. 14.c, pp.18-19; 31-32).

Commentary

The Application demonstrates an awareness of the problems that could arise if business expectations were unduly raised in the Study Region. While northern business certainly should hope to benefit from the pipeline, it should be discouraged from overemphasizing the prospect of quick gains. As a group, northern businessmen would not yet seem ready to participate more than marginally in a project as large as the proposed pipeline. Their interests, and that of the region, would best be served by gradual growth and diversification. It would seem particularly important that situations of excess capacity, where capital costs cannot be recovered in a relatively short period, be avoided. In most localities, the effects of the pipeline project will be short-lived; excessive investment in facilities such as hotels and restaurants where these are not warranted by normal population growth, could lead to disappointment and bankruptcy. The consequences would not be harmful only to the unsuccessful investor, but also to communities that had come to depend on these facilities for local employment.

Regional businessmen probably could improve their position with respect to the pipeline by forming industrial or commercial associations that could forward their special interests and provide the Applicant with information on their capabilities. These groups could deal on behalf of a particular industry or activity with the "Study Region Economic Liaison Group" proposed by the Applicant (Sect. 14.c, p.40).

In the long run, the pipeline should be beneficial to the private economy of the Study Region. The regional market will expand with the growth of population and per capita income. A gradual process of "import" substitution might be expected to develop, although a strong dependence on goods and services imported into the region will undoubtedly continue for many years.

With respect to major resources, a decision not to construct this pipeline probably would affect the timing of further oil and gas exploration in the Study Region. However, the Applicant may somewhat overstate the case that such exploration is specifically dependent on his facility and not give sufficient recognition to its dependence on growing world shortages of accessible and available hydrocarbons. If Mackenzie Delta gas is urgently needed by the Canadian or continental economy, some means, whether it is this particular pipeline or another method, will be found to bring it to market.

Highlights

1. The pipeline project should benefit the economy of the Study Region during the construction phase although care will have to be taken to ensure that business expansion to meet real or perceived pipeline requirements is not excessive and does not lead to redundant capacity after construction has been completed.

2. Regional businessmen could assist themselves by publicizing the kinds of products and services they can provide to the Applicant.

3. In the long run the pipeline should have a beneficial effect on the regional economy through being a factor in the creation of a larger and more diversified market.

4. The major resource most affected by the pipeline will of course be natural gas. While a negative decision on the proposed pipeline could retard plans for regional gas exploration and development, the timing of natural gas exploitation probably depends much more on national and international market forces than on whether this particular pipeline is chosen from among a number of alternative means of transportation.

3.8 COMMUNITY SOCIAL CHANGE

Background

Associated with the rapid growth of the non-Native population of the Study Region is the rapid growth of communities which are important to the extension of the northern frontier. Inuvik grew at an annual rate of 7.82 per cent during the 1961-71 decade, a rate that more than doubles a population in a ten-year period. Hay River grew at an annual rate of 6.19 per cent and nearly doubled its size. These two "action" communities comprised only 40 per cent of the population of the Mackenzie Corridor Impact Region in 1961; by 1971, they had grown to 49 per cent of this population (Forth, *et al.*, Figure 7, p.98).

Similar trends have been observed at other larger centres in both territories, and transient population has become increasingly concentrated at Inuvik, Hay River, Whitehorse, Yellowknife and Fort Simpson. Smaller communities have tended not to grow as quickly as larger ones.

Whether the proposed pipeline is built or not, the trend already apparent may be expected to continue even if the growth of activity in the Study Region is only relatively moderate. Any activity that moves into the region would naturally seek out the largest markets, the prime sources of labour, and the best locations from the standpoint of raw materials, services and finished products. The fact that serviced industrial and commercial land is available in some communities and that local councils have had some experience in dealing with businessmen would be viewed as positive attributes by potential investors. Because government facilities are already located at these communities, they would be logical sites for the expansion of government services.

Some form of local government exists in all communities of the Study Region, but the degree to which local people can make major decisions which may affect the development and well-being of their community is generally not very great. Yellowknife is the only city in the region; Inuvik, Hay River and Fort Smith have town status, while Tuktoyaktuk, Fort McPherson, Fort Franklin, and Fort Simpson are settlements. In each case, elected officials are responsible to the community, but because the local tax base is generally very small, only the largest communities have more than consultative powers with respect to most expenditures made within their boundaries.

In both the Northern Territories, the Territorial Government has a high degree of responsibility for municipal concerns. It collects locally generated taxes, license fees, and liquor profits, and reallocates these revenues among communities, providing services such as education, municipal works, welfare services, and general administration. Locally derived revenues tend to fall far short of expenditures, and substantial federal transfers are required by the territorial municipal fiscal process.

Impact of the Pipeline

Issues

The following are of particular consequence with respect to the topic under discussion:

(i) the effect of the pipeline on the size, character and function of various communities in the Study Region;

(ii) the effect of the pipeline on the problems of operating and maintaining communities.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references of relevance to the second issue (Guidelines 7 and 8) which have prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant intends to locate his regional operating centres at Inuvik, Norman Wells and Fort Simpson. He anticipates that the effect of increases in population related to longer term employment will be confined to these communities, and that the impact of the pipeline on smaller communities will be negligible.

With respect to activities related to construction, exploration and development, the Applicant states his intentions, and those of the petroleum industry in general, to confine these to larger communities or self contained camps. Because the larger communities have already developed some service industries, have a more substantial infrastructure, and will be the focal point of supply and service activities, they likely will be the prime recipients of secondary employment benefits related to the pipeline.

The Applicant makes specific reference to improving infrastructure in several communities, such as docks, wharves, and airstrips; to providing community services such as medical and dental facilities; to making available emergency supplies and equipment; and to sharing with community residents the recreational facilities developed for permanent employees. He believes that this will significantly improve the quality of regional infrastructure and level of community amenities (Sect. 14.d, pp. 39 and 40).

Staff housing and administrative maintenance buildings will be constructed in Inuvik, Norman Wells, and Fort Simpson, which should increase tax revenues of these communities. It also could ensure that pressures on existing housing, office and other facilities do not arise from development of the pipeline.

Commentary

With the construction of the pipeline, the growth of northern "action" communities may be expected to continue and perhaps even accelerate, especially in the Mackenzie Corridor Impact Region. Pressures are likely to be particularly severe in the Mackenzie Delta, and especially at Inuvik, where pipeline construction and operation will coincide with the development of gas fields and activities related to the logistical support of drilling operations in the Beaufort Sea area. Larger centres lying off the pipeline route, such as Hay River, Yellowknife, and perhaps even Whitehorse, also should experience some growth effects because of the pipeline project.

The pipeline will be only one of a number of sources of regional change during the next decade. The Mackenzie Highway and the development of northern hydrocarbon resources could have a greater long-term impact on the Mackenzie Valley than will the pipeline. From his figures, it certainly would appear that the Applicant expects the pipeline to have a lesser employment impact than would the development of Mackenzie Delta gas resources.

How might the populations of the smaller communities fare through all of this? Projections such as the Applicant's and those of the TFNOD report suggest the harmonious, if not particularly rapid, growth of such communities. It would appear that they are expected to continue to function mainly as Native hunting, trapping and fishing settle-

ments, and as sources of unskilled labour. The possibility that some communities could undergo a decline in importance and perhaps even in population has not been considered. Yet this is a possibility.

The present small communities represent economic and social adaptations to a subsistence way of life that was formerly widely prevalent in the Mackenzie Valley and which is optimally suited to the purposes of people who have to derive a subsistence living from a variety of sources; who, moreover, must spend some time "on the land" and some time in communities where modern amenities, welfare and some wage employment are available. Quite apart from their social and cultural aspects, a basic economic fact underlying these communities would seem to be the uncertainty of the annual income that people can derive from the land, and the need for people to be near as many income sources as possible to compensate for this. If one combination of income sources fails to provide a subsistence living, some other combination may. Typically, workers in such communities try their hand at a number of things throughout the year - seasonal and casual jobs, hunting, trapping and, if need be, welfare.

Only people who have had the experience of permanent employment and income (and, moreover a positive experience of it) feel any kind of commitment to steady work. Where employment opportunities have fluctuated rapidly, there has been no time to develop the kind of psychology that is necessary to seeking and holding a permanent job. Where experiences with wage employment have not been positive or reinforcing - and there have been many such instances - people often have become cynical and have tended to dismiss overtures and promises that are made about long-term employment.

Two lines of conjecture can be put forward about future employment in the Study Region: First with events such as pipeline construction and much more hydrocarbon exploration and development in the offing, increasing wage employment should certainly be available to people of the Mackenzie Valley. Such employment will be particularly attractive to younger people who increasingly operate out of a different set of values and aspirations than their parents. Second, because much of the new wage employment will be offered by large companies with sufficient resources to provide sound training and comfortable camps, monitored by government, there is a better than average chance that Native people will find work experiences positive.

Such factors, while favourable in many ways, could have the effect of eroding the economic and social basis of small territorial communities. Perhaps the only way in which such communities might retain some long-run economic basis for survival would be by developing meaningful economic opportunities based on the entire community as a productive unit which is somehow integrated with the expanding regional economy. Unless there were strong inducements to keep them there, increasing numbers of people from these communities would tend to seek opportunities elsewhere. If this were to happen at a rapid rate, then at some point, a small community could find it difficult to function.

Local men who were employed on the pipeline project, in petroleum exploration and development, or on jobs such as highway construction, and who would return home during off-work periods with cash and liquor, could introduce new pressures, values, and modes of behaviour that small communities might find difficult to accommodate, particularly if, as is likely, strong kinship ties were still a major factor in such communities. This could lead to a deterioration of the quality of local life and add to pressures inducing people to leave.

On the matter of the territorial municipal fiscal process in the Study Region, the Applicant's proposals for community improvement could create problems as well as beneficial effects such as improved community infrastructure and an increased local tax base. One source of problem could be the disruption associated with building, improving and using facilities such as local airstrips and docks for pipeline purposes. While a small community may emerge with better facilities following the completion of the pipeline, access to the community may have been impaired for some period of time during pipeline construction.

There are also questions of who would bear the costs of permanently operating and maintaining enlarged facilities left behind by the Applicant. At present, a small community airstrip or dock may cost little to maintain and operate. Typically, community airstrips may not be licensed and, although they are built to a low standard, they are adequate for irregular or emergency use during much of the year. Facilities required by the Applicant will have to be larger and of a higher standard, and accordingly will be more costly to maintain than present local facilities.

Highlights

1. During the past decade, economic development in the Study Region has resulted in the rapid growth of larger communities such as Hay River and Inuvik. This trend likely will continue and accelerate due to the pipeline and other major activities such as oil and gas exploration and development.

2. With growing wage employment opportunities away from the community, smaller centres of the Study Region could undergo increased out-migration unless steps were taken to counter such tendencies. If the out-migration process were carried beyond a certain point small communities could find it difficult to function.

3. Social pressures on small communities could be aggravated by disruptions caused by local men returning from jobs on the pipeline, etc., during off-work periods.

4. Construction and improvements which the Applicant proposes could result in disruption of normal community access to facilities and costly maintenance of new or enlarged facilities the Applicant might leave behind.

3.9 COMMUNITY ENERGY ALTERNATIVES

Background

For communities in the Study Region, present sources of energy consist of hydro-electric power, fuel oil and wood. Hydro-electric power is supplied to Yellowknife, Pine Point and Fort Smith from generating stations on the Snare River and on the Taltson River. In these communities, diesel-powered generators are also used to serve as back-up supply and stand-by units. Other communities must rely on oil-fuelled generators for their supply of electricity. For heating, the chief energy source is fuel oil, although smaller settlements and some homes in larger communities still rely on wood for home heating. Utilidors are used to conduct heat to parts of Inuvik, Fort McPherson and Norman Wells. In Inuvik, steam heat is supplied from a large thermal generating plant (Gemini North, Vol. 4, Sect. 5.4). Diesel oil provides heating for the mines at Pine Point and Yellowknife, as well as heat for homes and larger buildings.

The Northern Canada Power Commission is the major utility company supplying electricity in the Study Region, but the distributor for the NCPC in the Yellowknife area is Plains Western Gas and Electric, while Hay River/Enterprise and Fort Providence are served by Alberta Power Limited. Oil for heating and the generation of electricity is supplied from two sources. The refinery at Norman Wells supplies about 11 million gallons of oil per year to Mackenzie River communities north of Norman Wells and along the Arctic coast. The remaining requirements of the Study Region are transported to Hay River by rail and, from there, by barge to communities south of Norman Wells (O&GA, 1973, and Underwood, McLellan, p.8.1).

The NCPC hydro-electric generating station on the Taltson River supplies about 20,000 Kw/year to Pine Point and Fort Smith. This does not cover heating requirements. In Pine Point alone, in addition to hydro-electric power, three to four million gallons of oil are required per year to provide heating for the mine and town-site, as well as for the operation of the concentrator. The Snare River hydro-electric generating station, with two generating units and a total capacity of 14,000 Kw/year, supplies power to the Yellowknife-Rae-Edzo area, which includes the settlement of Dettah and the Giant Yellowknife and Con-Rycon mines. It is supplemented by an additional 7,000 Kw made available from diesel-fuelled generating units (information provided by NCPC). It is estimated that, in 1973, about 7 million gallons of oil were used in the Study Region to generate electricty at a cost of about $1.88 million (NCPC data).

Costs per gallon to householders for heating oil are, in general, higher than the cost of oil to utility companies. The price of heating oil varies from community to community. In 1973, such variations ranged from less than 25 cents per gallon at Norman Wells to almost 39 cents per gallon in Fort McPherson. About 6.5 million gallons of oil were used for domestic heating in 1973 (Underwood, McLellan, p.8.1).

Impact of the Pipeline

Issues

The following issues are considered important with respect to the question of energy sources for Study Region communities:

(i) the effect of the pipeline on the feasibility of supplying natural gas fuel to

communities at a cost competitive with fuels such as oil and electricity;

(ii) the degree to which the pipeline and its related gathering plants or other operations could facilitate the development of alternative sources of fuel such as propane gas, or of alternative energy production and delivery systems.

Applicant's Statement

The Applicant points out that he is constructing a transportation system only. He will not own any natural gas, nor will he build or operate any natural gas distribution facilities in the territories. However, he will, where desired, install valves and fittings at appropriate points as a convenience to future construction of distribution facilities, and will cooperate in the planning and development of gas distribution systems. To this end, he has undertaken studies concerning the technical and economic feasibility of gas supply for Study Region communities (Sect. 14.c.5.9.1).

Commentary

To date, the Applicant has not made available any studies he has undertaken as to the technical and economic feasibility of gas supply for Study Region communities.

Several alternative sources of energy for community use have been given some consideration in the context of the pipeline project. A study completed by the consulting firm of Underwood, McLellan in May, 1974, examined the comparative costs and feasibility of oil, natural gas and hydro-generated electricity as alternative sources of light, heat and power for Study Region communities through 1980 to 1995. This included a detailed examination of a "typical" community, and Fort McPherson was used for this purpose (Energy Alternatives, Underwood, McLellan, 1974). The comparative costs estimates given below are based on data obtained from this study.

Insofar as oil is concerned, purchase price at source is a major component of unit selling price. Therefore, unit selling price tends to vary directly with changes in purchase price and, to a relatively small degree, with distance from source and transportation costs. A change in the volume consumed by a given community has little effect on the unit cost of fuel to that community.

However, both electricity and natural gas require the construction of specialized sub-transmission and distribution systems. In both cases, but especially in the case of natural gas, a very large factor affecting the unit selling price to the consumer is amortization of the high capital costs of the delivery system. These costs increase with the distance of the community from the main trunk pipeline. Effects of variation in purchase price of the fuel at source are therefore proportionately small, but an increase in the volume of fuel delivered to a given community would tend to lower the unit selling price to the consumer. Therefore, unit cost to the consumer would be lowest for communities close to the pipeline, with large fuel requirements, and very high, comparatively, for communities farther from the main trunk line or for communities using small annual volumes of fuel.

Costs of building gas transmission lines vary from about $84,000 per mile for a two-inch pipeline, to about $145,000 for a 10-inch line (Underwood, McLellan, Appx. 3, p.A.3.2). Costs of constructing sub-transmission systems, including transmission line costs, would vary from about $754,000 in the case of Fort Good Hope and Norman Wells, to $24.5

million for Hay River and $73.4 million for Yellowknife. These last would not include costs of local distribution systems, purchases of new furnaces or conversion of present ones, or maintenance and other costs.

As the "typical" community used for purposes of detailed analysis in the Underwood, McLellan study, Fort McPherson is relatively close to the proposed pipeline, being only about 4 miles from the right-of-way. The study assumes a 4 per cent annual increase in the population of the community, which would grow from an estimated 840 people currently to about 1,063 in 1980, with a corresponding increase in fuel consumption. The study estimates that the cost of oil, delivered to Fort McPherson in 1980, will be 65.5 cents per gallon, rising to $1.105 per gallon by 1995. Estimated cost of natural gas at the main trunkline will be 66.5 cents per Mcf in 1980, rising to 96.5 cents per Mcf by 1995.

Cost at main pipeline, however, represents only a fraction of the cost of delivering natural gas fuel to a community. Underwood, McLellan estimate that natural gas which costs 66.5 cents per Mcf at the main trunkline will cost about $6.77 per Mcf, or more than 10 times as much, when delivered to the user in Fort McPherson. The final unit cost to user includes cost at source, costs of the sub-transmission and distribution system amortized over 30 years, plus maintenance and related costs, and as described previously, is significantly dependent on the total volume consumed by the community.

If, as is indicated by Underwood, McLellan, the energy output of 1 gallon of oil is equivalent to the energy output of 128.8 cu ft of natural gas, the cost to the Fort McPherson user of the equivalent amount of energy from natural gas would, in 1980, be about 87 cents, as compared to 65.5 cents for oil. Thus the cost of natural gas would be almost 35 per cent higher.

Taking into account distance from pipeline and size of community, Underwood, McLellan estimated that, in 1980, only three communities would realize a saving through the use of natural-gas fuel instead of oil. However, by 1995, twelve communities would have passed the break-even point (Underwood, McLellan, Table 6.1 and Appx. 3, Table 2). If all Mackenzie Valley communities were to convert to natural gas energy by 1980 as a replacement for present fuels, energy costs for the Study Region would be considerably higher than if oil were used. The break-even point in cost would not be reached until after 1991 for the region as a whole (Underwood, McLellan, Plate 6.1 and Summary, p.v.).

From such information as is at hand, it would not seem that hydro-electric power is a viable source of energy for either the pipeline or most Study Region communities at present. Operating the pipeline by using hydro-electric power would require damming a major watercourse, and whether the necessary authority could be obtained for this is not known.

The Applicant intends to use natural gas as his energy source during the operations phase. He proposes to install the equipment necessary to tap natural gas from the main trunkline at his compressor stations. Such equipment will include pressure reduction units, fuel gas scrubbers and electrical power generating equipment. To operate compression and refrigeration equipment and to supply station light, heat and power along the Canadian portion of the pipeline will require from 28.85 MMcf per day, or 2.3 per cent of through-put in the first year, to 277.8 MMcf per day, or over 6 per cent of through-put, in the fifth year (Alignment Sheets and Flow Diagrams, Sect. 1.1 to 1.10).

This suggests a possible method of supplying energy to communities that are far from the pipeline or are too small to be served economically by construction of high-priced natural gas sub-transmission and delivery systems. No studies have yet been made concerning the cost and feasibility of using natural gas to power generators adjacent to the pipeline and of carrying the electricity so produced to communities. However, costs of constructing a power-transmission line from the pipeline right-of-way to Yellowknife would be about one-third of the cost of a comparable natural gas transmission system (Underwood, McLellan, Tables 5.1 and 5.2, 1974).

It might be feasible, at certain locations, to install natural gas-fuelled generator units for community electricity generation adjacent to compressor stations, and to share with the Applicant such facilities as valves, fittings, and pressure reduction and scrubbing units which he will be required to install for his own purposes. This could possibly result in considerable savings to both the Applicant and the public utility. However, the complete cooperation and agreement of the Applicant would be required to develop appropriate facilities and arrangements for joint use.

Another alternative which should receive consideration involves the use of liquid propane gas. This possibility depends on the composition of future gas discovered in Canada for transport through the pipeline. Gas discovered in the Mackenzie Delta to date is very dry, containing only 0.9 per cent propane. However, natural gas from Prudhoe Bay contains about 4 per cent propane. It is possible that further discoveries in the Northern Territories, tapping new pools, will carry a higher percentage of "liquids".

Natural gas liquids in any quantity would normally be removed in drying units at the gathering plants. The propane so removed could be stored in large containers at the gathering plant and shipped by barge to storage units at centres such as Inuvik, Fort Simpson, Yellowknife and Hay River, where bottling plants could package the propane into standard, easily transportable containers. By this method, even communities at considerable distance from the trunk pipeline could be supplied with propane gas at not much greater cost than communities near the pipeline, since the use of standard means of transport would eliminate the need for secondary pipeline construction.

Bottled propane is easy to transport and simple to use. Standard appliances for propane use are available on the market. Its combustion rating, at 2315 Btu/cu ft, is more than twice as high as that of natural gas.

It must be stressed that neither the foregoing possibility nor that of generating electricity for community use along the pipeline right-of-way have as yet been subjected to authoritative study. They are included in the present report merely to ensure that some attention is given to them.

Highlights

1. From the limited study that has so far been given the subject, it would appear that natural gas would probably be competitive with oil or electricity at only a few communities in the Study Region during the early years of pipeline operation. These communities would be within a short distance of the main natural gas trunkline and would have populations large enough to generate a relatively high annual demand for fuel and energy.

2. Growth of community size would, over a period of time, lead to an increasing number of communities realizing a cost advantage from natural gas.

However, in the case of some communities, natural gas will not likely ever be economically feasible.

3. Other sources of energy and fuel such as electricity generated for community use along the pipeline right-of-way, and propane gas, could become available as a result of the pipeline but, to date, no studies have been conducted as to cost and feasibility.

3.10 GOVERNMENT REVENUES AND EXPENDITURES

Background

Government of Canada activities in the Study Region include the administration of lands, waters, forests and major non-renewable resources such as oil, gas and minerals; environmental protection; Indian and Eskimo affairs; provision of major transportation links; and research. The Government of Canada also has the prime responsibility for programs administered on its behalf by the territorial governments.

Data on federal revenues and expenditures for the whole of the Northern Territories indicate that in calendar year 1970, the most recent year for which complete data are available, the Government of Canada spent $179.7 million on the region, 36 per cent, or $64.6 million, being for transfers to the territorial governments. Offsetting federal expenditures are revenues from a variety of sources such as personal and corporate income taxes; indirect taxes; licenses, permits, fees and royalties; and principal and interest repayments from the territorial governments. In total these revenues amounted to $65.7 million in calendar year 1970. The largest single component was personal income taxes which amounted to $21.3 million or 33 per cent of the total. Revenues from the sale and exploitation of natural resources were relatively minor, amounting to $7.6 million or 12 per cent. Total revenues in 1970 amounted to only 37 per cent of total expenditures, and the over-all federal deficit equalled $114.0 million (Palmer, 1974, Table 7).

The territorial governments administer a wide range of programs which include education, health, welfare services, development of local government, municipal public works, and housing. Both territories, however, have a very limited tax base. Not only is population small, but much of this population is of low income, particularly in the Northwest Territories. Property taxes go mainly into the territorial treasury, but the property tax base is also limited because the territories are at an early stage of development. Moreover, much of the population does not own property and therefore is not subject to such taxes.

Costs of the services provided to the people of the two territories are high because of factors such as distance, small community size, and the severe climate. Each territorial government, therefore, incurs large annual deficits. Territorial expenditures have climbed rapidly during recent years, especially in the Northwest Territories where costs are particularly high, and the range of services provided by government has been greatly expanded over a short time period. In many communities recreational facilities and other amenities, which would have a positive effect on the quality of life, are still either very limited or non-existent. Adequate housing is commonly in very short supply, and overcrowding is commonplace.

In calendar year 1970, the Government of the Northwest Territories spent a total of $75.3 million on its various programs. Revenues accruing to the Government of the Northwest Territories in 1970 have been estimated at $74.1 million, of which $53.2 million or 12 per cent came as federal transfers. The Government of the Northwest Territories thus was able to raise only 16 per cent of its revenues during 1970.

The Government of the Yukon Territory also was unable to meet more than a limited proportion of its costs. Calendar year 1970 expenditures have been estimated at $26.1 million. Revenues in 1970 were $24.9 million, of which $11.4 million

or 46 per cent represented transfers from the Government of Canada, and an additional $5 million or 20 per cent consisted of federal loans. The Government of the Yukon Territory therefore met only about 30 per cent of its 1970 revenue requirements (Palmer, 1974, Tables 8(a) and 8(b)).

Impact of the Pipeline

Issues

The only subjects considered in the present discussion are:

(i) the effect of the pipeline on federal revenues and costs relating to the Northern Territories;

(ii) the effect of the pipeline on territorial revenues and costs.

Obviously, these are very large and complex issues, and many aspects of them are implicit in the contents of this entire report. Only a very general treatment, which focuses on the most immediate effects of the pipeline on government revenues and expenditures, is attempted here.

Applicant's Statement

The Applicant does not say anything about federal or territorial revenues or expenditures as such. However, he does make statements about a number of matters that could significantly affect government costs in the Study Region. For example, he indicates that during pipeline construction he and his contractors will not significantly burden existing community facilities, services and housing. During both the construction and post-construction phases of the pipeline, he intends to provide recreational facilities, in cooperation with local residents, for staff located in communities. Any resulting facilities will be regarded as equally available to all community residents. He also indicates he would be willing to share medical and dental facilities that he would provide to meet his requirements (Sect. 14.c, p.30, and p.37, para 2).

Commentary

Of all the possible revenue streams accruing to the Government of Canada from the proposed pipeline, only revenues from royalties on Canadian natural gas transported through the pipeline, right-of-way charges for crossing Crown lands in the territories and stumpage and quarry fees can be directly associated with the natural resources of the Study Region. Such revenues have been estimated by one study as equalling about 11 to 13 per cent of the total revenues from the pipeline accruing to the Government of Canada during the 1976-1999 pipeline construction and operation period. The only substantial item among them would be natural gas royalties (Manders, 1973). Other significant revenue streams will derive from sources such as individual and corporate income tax. However, estimates of portions of such revenues that may be attributed to activities in the Northern Territories have not been made.

Would these regional revenues be large enough to have an appreciable effect on the deficit in federal spending in the territories? The Applicant projects total volumes of gas moving through the proposed pipeline at 4.5 billion cu ft/day during the fifth operating year. Of this, 2.25 billion cu ft/day would come from each of United States reserves at Prudhoe Bay, Alaska, and Canadian reserves in the Mackenzie Delta. Canadian annual production therefore would amount to some 820 billion cu ft. If, purely for the sake of illustration, a well-head price for gas at 40¢ per thousand cu ft during the mid-1980's, and an average royalty rate of 12.5 per cent could be assumed,

annual royalties could amount to $41 million or about 36 per cent of the estimated 1970 deficit on over-all federal operations in the Northern Territories (Manders, 1973, p.46).

It would be most difficult to judge the net effect of the Applicant's proposed actions on matters that are of concern to the territorial governments. It can be said with some certainty that the effect on the Government of the Yukon Territory will not be great or demanding. In the case of the Government of the Northwest Territories, matters will be quite different. On the one hand, the kinds of programs that the Applicant proposes to undertake would be helpful and could serve to advance regional and local development objectives. On the other hand, the pipeline undoubtedly will raise costs that only government will be in a position to bear.

Direct effects on territorial revenue streams probably will be relatively moderate. The Northwest Territories Taxation Ordinance recently has been amended to permit a tax rate of 25 mills to be applied to the assessed value of a pipeline. Using this rate and an assessed pipeline value of $117.1 million, the Government of the Northwest Territories has estimated annual revenue deriving from the proposed pipeline at close to $3 million. This does not take into account the assessed value of compressor units, auxiliary pumps, smaller diameter connecting pipes and other related structures that cannot be evaluated at present.

Another analysis, which uses a tax rate of 30 mills for each of the Northwest Territories and Yukon Territory, and which assumes that the assessed value of the pipeline will diminish over time, estimates that revenues gradually could decline from $4.58 million to $1.78 million annually for the Northwest Territories between 1978 and 1999, and from $980,000 to $380,000 annually for the Yukon Territory during the same period (Manders, 1973, p.51). Using a discount rate of 8 per cent, total present (1973) value of future revenue streams accruing from pipeline property taxation would range from $20.0 million to $33.3 million for both territories (Manders, 1973, p.61). This would include taxation of real property ancillary to the pipeline. In addition, the territorial governments would realize relatively minor revenues from items such as fuel taxes during construction, which have been estimated at $3.2 million in total (Manders, 1973, p.61).

Highlights

1. Revenues from royalties on Canadian natural gas would be the most significant source of pipeline-induced revenues accruing to the Government of Canada from revenue sources most directly associated with the resources of the Northern Territories.

2. Revenues accruing to the governments of the two territories would appear to be relatively moderate, and could derive mainly from the taxation of the pipeline as real property.

3. While the territorial governments will gain revenues from the pipeline, they also will experience increases in some costs. The net result is uncertain.

CHAPTER 4

SECTORAL ANALYSIS

4.1 Introduction

This section of the report examines the present status and likely future role of various industrial and governmental activities of the Study Region, and attempts to assess the influence that the proposed pipeline may have in their evolution. While analyses of individual activities may go into detail on some occasions, the prime concern is to establish general trends.

The activities discussed cover a broad spectrum. The "traditional" hunting, trapping and fishing activities long associated with the lifestyle of Native people, stand in marked contrast to the highly technical pursuits of oil and natural gas exploration and development. The latter have recently become powerful agents of economic and social transformation in the Northern Territories. Change, brought about by the influx of a relatively high-income population from southern Canada has rapidly created small business opportunities for entrepreneurs. It has also created a requirement for a wide range of social services and government activities.

The sequence of the material that follows is intended to reflect the approximate economic character of various activities. The first several sections deal with primary activities such as hunting, trapping and fishing, oil and natural gas, mining and tourism. These are followed by a discussion of such "infrastructural" activities as transportation, communications, and construction. A third category includes the relatively small secondary and tertiary industries of the Study Region under topics such as trade and commercial services. Last, but by no means least in terms of their importance, is a discussion of some of the main governmental activities that could be affected by the pipeline.

A considerable body of material has recently been made available on many aspects of the northern economy and society, and the reader interested in additional background should refer to the bibliography at the end of the Introduction to the socio-economic part of the report.

4,2 TRADITIONAL ACTIVITIES

Background

This section deals with hunting, trapping and fishing, the so called "traditional activities", as a group because of the importance of these pursuits to the economy of the Native people of the Study Region. In the discussion, hunting and fishing do not include sports hunting and fishing or commercial fishing. These topics are dealt with elsewhere in the report. (*see* "Tourism" and "Commercial Fishing").

At present, only a few communities of the Study Region are still heavily reliant on hunting, trapping and fishing. (Gemini North, 1974, Vol.5, Table 4.1). Very few Native families live exclusively either from cash or income in-kind gained directly from the land. For most communities, the typical family derives its livelihood from a mixture of wage employment and resource harvesting, with trapping providing extra cash and hunting and fishing providing much of the family's food requirements. (Bissett,1973, p. xii; TFNOD, D.5.2; Gemini North, Vol. V, p.62-3).

Gemini North gives the value of the products of hunting, trapping and fishing as about $1.4 million in 1972. (Gemini North, 1974, Vol.V, Table 4.1, p.58). While the value of the output of traditional activities did not decrease in absolute terms between 1969 and 1972, their share of the Study Region's total income fell from between 6 and 7 per cent to approximately 3 per cent during this period. (Bissett, pp. 5-34, Gemini North, Vol. 5, Tables 2.6, 3.2, 3.3, 3.4, 3.5 and 4.1).

Trapping has been the main source of cash income within the traditional economy, but its role as an economic activity has declined steadily during recent decades. A variety of factors have been responsible for this, among the most important being a secular decline in the demand for wild furs and an increase in cash income from other sources such as wage employment. As an indication of the longer term decline of the fur industry, the gross number of pelts produced in the Northwest Territories as a whole in 1972-73 was less than 15 per cent of production in the late 1940's (Gemini North, Vol.5, Table 2.5 and Rea, p.386). Returns to trappers attained during the 1940's have not been equalled since. Recently, however, fur prices have increased sharply to the extent that the gross value of wild fur produced in the Study Region between the 1968-69 and 1972-73 fur years remained at a relatively constant $600,000 despite an approximate 70 per cent decrease in pelt production (Gemini North, Vol.5, Tables 2.5 and 2.6). Principal species trapped in terms of gross value of product are, in order, muskrat, beaver, lynx, marten and mink (Derived from Game Division, N.W.T., Data - unpublished, 1974).

Hunting, which is closely linked to cultural preferences as to diet among Native people, has been declining relatively slowly as a component of the traditional economy. Gemini North places the value of hunting output at $500,000 in 1970-71 and about $400,000 in 1971-72 (Table 3.2). Principal species hunted for meat in the Study Region are caribou, moose and black bear. The number of moose and bear taken has decreased during recent years, although the take of caribou has remained relatively stable (Gemini North, 1974, Vol.5, Table 3.1, p.39).

Despite a gradual downward trend in hunting the number of general hunting licenses at selected Study Region communities increased by approximately

44 per cent during the 1960's. During recent years about 75 per cent of these licenses were issued to Native people (Bissett, 1974, pp.5-70).

Gemini North estimates the value of the 1972 domestic fishing harvest in the Study Region at close to $300,000. Approximately 273 families are said to have participated in domestic fishing activities which were mostly carried out during the summer and early fall. Total volume of fish caught for domestic use in 1972 is estimated by one source as under 1 million pounds (Gemini North, Vol.5, Table 3.3), a figure that suggests a decline from previous years. Currently, in terms of volume, the domestic fishing catch is equivalent to between 25 and 30 per cent of the volume of commercial fishing.

While more than 1,000 persons in the Study Region still undertake some hunting and trapping, there are indications that less than 100 are still full-time hunter/trappers. Declining harvests in hunting and trapping indicate that Native hunters/trappers are spending less time at these activities and more time in seasonal wage employment. However, declining harvests may in part indicate a decreasing, or less accessible, resource base, particularly in the vicinity of communities. There is also, perhaps, an increasing reluctance on the part of the Native provider to spend much of the year away from his home and family who, to an increasing extent, must remain in the settlement, near schools and other facilities.

The role that land resource harvesting may continue to play in the northern economy is uncertain. Share of total income varies from less than 1 per cent in Norman Wells, Yellowknife and Hay River to 50 per cent and more in Fort Good Hope and Old Crow (Gemini North, Vol.5, Table 4.1). Using a sample of families in selected Study Region communities, one source estimates that between 55 and 70 per cent of the meats consumed by Native families are of local origin. Trapping accounts for only a small part of a typical hunter/trapper's cash income, as the average return per trapper in 1972-73 was only about $500 (Bissett, 1974, pp.21-23). However, the strong dependence on game as income in kind will probably continue indefinitely, even though trapping may continue to decline with the spread of wage employment.

As a group, land-based activities give a certain stability to a generally unstable local economy. A basic reason why so many people still "keep a hand" in trapping is because it is nearly always possible to make some money by pursuing this activity if other sources of income should fail, as has often been the case in areas such as the Mackenzie Valley. While trapping (and also hunting and fishing) may be a difficult way of making a living in comparison with many forms of wage employment, it has always been available to fall back on, whereas wage employment has typically been available only intermittently in most localities and for most Native people.

As well, the special role that land-based activities have played in the culture of northern Native people must not be overlooked. Because these activities are so much a part of their heritage, some Native people - and perhaps a considerable number - may not wish to forego hunting, trapping and fishing as a way of life regardless of the economic penalties of remaining in this sector. Certainly, the back-to-the-land movements that have arisen in the Northern Territories in recent years indicate that the choice between wage employment and more traditional pursuits, at least on a part-time basis, is not resolved.

Impact of the Pipeline

Issues

The following appear to be of particular importance with respect to hunting, trapping and fishing:

(i) any effect that the pipeline may have on traditional land resource harvesting areas and on the fish and land-animal resources used by Native people;

(ii) the effect of pipeline construction in providing wage employment as an alternative to the traditional activities;

(iii) the long-term effect of the pipeline on hunting, trapping and fishing.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines", provided a basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant notes past trends away from traditional pursuits in the Study Region, suggesting that such trends may now have become irreversible (Sect.14.c.2.1 and 2.2). However, he contends that the construction and operation of the pipeline will probably be neutral in terms of its impact on game, fur and fish, and the ability of residents of the Study Region to harvest these resources (Sect.14.c, 4.8.1).

The basis for this contention is two-fold: first, the Applicant states that environmental changes capable of altering or disturbing utilized areas will be minimized and that possible adverse influences of the construction labour force will be kept to a minimum by the Applicant's policies. Second, he notes that traditional activities account for only a small percentage of the Study Region's total income and that these activities are economically important only in some of the smaller communities, whereas the long-term impact of the pipeline will be concentrated in the larger communities (Sect.14.c.4.8.1).

Commentary

The pipeline will traverse traditional resource harvesting grounds along much of the right-of-way. Moreover, some of the Applicant's permanent roads, compressor stations and airstrips will also be situated in traditional harvesting grounds. While there is insufficient information available to enable the detailing of specific problems that could arise from this, there is at least some possibility that conflict between the pipeline and traditional uses of the land could occur in a number of locations, over the life of the pipeline. The "Requests for Supplementary Information" have solicited additional information in this regard.

The pipeline will likely have the effect of directly reducing the participation of Native people in traditional activities. Several sources agree that the proportion of the prime labour force (people between 20 and 49 years of age) engaged in these activities could decline significantly during pipeline construction (Bissett, 1974; TFNOD, 1974; Gemini North, 1974). Following completion of the pipeline, some Native people would likely return to traditional pursuits, particularly if there were a significant decline in the regional demand for labour. In any event it is unlikely that participation in the traditional sector will ever return to pre-pipeline levels.

Regardless of the regional level of employment or unemployment, many Native people, once they are exposed to wage employment and the relative com-

forts of camp life, may be reluctant to return to the rigorous and uncertain life of the trapline. Many younger workers will have had only limited experience with trapping in the first place, and may have few of the skills required for a life on the land.

During the pipeline construction, a number of social and economic pressures could make it difficult for Native workers to resist taking wage employment. Relatives, friends and neighbours could provide a constant demonstration of the material advantages of "getting a good-paying job". Social status might become increasingly correlated with high wages and material possessions. As well, direct economic pressures such as prices that exceed the ability of low-income hunters/trappers to meet them could, if they occurred, tend to drive Native people out of the traditional sector.

Of the various traditional pursuits, trapping would be the most seriously affected. One study suggests that during pipeline construction, trapping returns could decrease by as much as 70 to 80 per cent in communities close to the right-of-way (Bissett, pp.5-53). The fine-fur season, coinciding with the peak pipeline construction season, would be particularly affected if substantial numbers of Native people joined the pipeline work force. It is unlikely that Native workers could simultaneously pursue trapping and pipeline employment. Even leave periods would probably not allow for sufficient time to operate a trapline.

Hunting and fishing may not be greatly affected by the withdrawal of labour for pipeline construction. The taking of fish and game may decrease during the construction period because many Native men may earn sufficient cash income to make hunting and fishing not worth pursuing. However, hunting could still be pursued during leave periods; it is not nearly as seasonally specific as trapping. Many Native people will probably hunt during the off-construction (summer) season. As most domestic fishing is conducted during the summer, it is unlikely that the pipeline's labour requirements will have much effect on the domestic fishery.

Permanent pipeline employment will be located mainly at Inuvik, Norman Wells, and Fort Simpson, which the Applicant has designated as his regional operational centres. At these communities, and perhaps at others such as Hay River, such traditional activities as are still practised will probably be affected, both by increased alternative employment opportunities and by pressures of population growth on the resource base of surrounding areas.

The pipeline will be only one source of growth for such communities; they are likely to grow for many reasons, some of which are not directly related to oil and natural gas activity. Native people who attempt continued reliance on traditional land-based activities at such communities will find it increasingly difficult to do so. Participation in hunting and fishing may however take on a more recreational orientation for both Native and non-Native residents of the Study Region. In addition, Native people could perhaps develop outfitting and lodge businesses that would cater to the sport hunters and fishermen of larger communities. However, any such undertakings would require substantial financial backing and expert managerial advice.

In communities which the pipeline will not affect directly and permanently, disturbances to traditional activities will be of shorter duration, and will be confined mainly to the pipeline construction period. The end of construction will signify the ending of something of a boom period in the case of most of these communities. At least some of the men who were employed in pipeline construction will have little alternative but to re-inte-

grate into their community and their previous occupations. Under these conditions traditional activities would probably make a considerable comeback. However, participation in them will probably never return to pre-pipeline levels.

Highlights

1. The over-all dependence of Native people of the Study Region on traditional hunting, trapping and fishing has declined during recent decades. Currently only a small proportion of the native labour force is fully dependent on trapping. However, there is considerable part-time trapping, for cash, and continued strong dependence on fish and game for food.

2. The spread of wage employment has been one factor accounting for the decline of the traditional economy. While many Native people might now prefer wage work, such wage employment as has been available to date in the Study Region has been relatively short-lived. Native people have therefore been reluctant to commit themselves to it, and have used land-based activities as a secure and more certain alternative.

3. The pipeline could affect traditional hunting, trapping and fishing directly because the right-of-way and many permanent facilities will traverse or impinge upon traditional resource harvesting areas. Potential effects of pipeline development on mammals and fish are reviewed in the environmental assessment part of this report.

4. Less directly, construction of the pipeline and associated activities could introduce a variety of pressures inducing Native people into pipeline or other wage employment. Particularly important might be the demonstration effect of higher incomes earned, and of increased spending by friends and neighbours, as well as the real economic pressures of rising costs and prices.

5. During employment on the pipeline, it will probably be very difficult for Native workers to maintain their traplines because peak trapping activity and pipeline construction will be seasonally coincidental. While much hunting also takes place in winter, it can be undertaken during other times of the year. The effort that Native people put into fishing would be only marginally affected by the pipeline, as much of the fishing is normally done in summer.

6. In the long term, the pipeline and other activities will likely reduce Native participation in traditional activities, particularly at or near larger communities, where such activity is declining in any event. However, the growth of population and income in the Study Region could provide Native entrepreneurs with opportunities in other fields, such as outfitting and fishing lodge operation that could utilize the skill and knowledge that is required in renewable resource harvesting.

4.3 OIL AND NATURAL GAS

Background

The oil and natural gas industry is the most important component of the private economy of the Study Region and of the Northern Territories as a whole. According to one source, 1970 expenditures in the oil and gas sector amounted to 54 per cent of all private investment in the territories (Palmer, 1974, Table 9B, p.57).

Exploration expenditures increased at an annual rate of 48 per cent, from $24 million in 1967 to an estimated $250 million in 1973. Well-drilling expenditures rose from 43 per cent of total expenditures in 1967 to 69 per cent in 1973 (O&GA, 1973). This indicates a shift from the more preliminary stages of exploration to the actual testing of possible hydrocarbon deposits.

Historically, the Study Region has been the focus of much of the northern exploration effort. From 1921 to 1973, 650 wells were drilled in the region, which represents 86 per cent of all wells drilled in the Northern Territories. Of these, 170 wells or 26 per cent of the total were drilled between 1971 and 1973. While the number of wells drilled in the Study Region has not changed greatly during recent years, the location of exploration has shifted northwest from the Slave and Upper Mackenzie Sub-regions to the Lower Mackenzie/Delta, the Northern Yukon, and the Central Mackenzie ("Schedule of Wells," 1921-1971, 1971-73).

Very recently, there has been some indication of a slow-down in exploration in the Northern Territories. Seismic and geological surveys, averaged 370 to 380 crew-months of employment in 1971 and 1972, but fell to approximately 210 crew-months in 1973 (O&GA, 1971, 1972, 1973).

There are two producing fields in the Northern Territories, the Norman Wells oil field and the Pointed Mountain gas field. Both are small operations by Canadian standards. Norman Wells underwent major development during World War II when there was an urgent military requirement for petroleum in Alaska. Since the war, all of its products have been used to meet demands in the Mackenzie Valley and along the Arctic Coast. In 1973, the field produced 2,802 bbl/day of petroleum from 59 wells. This is not enough to meet the needs of the small, but growing, regional petroleum market, and considerable additional fuels are imported to the region. Reserves are estimated at 42 million barrels (O&GA, 1973). The Pointed Mountain gas field, which is located in the southwest corner of the Study Region, commenced operations in 1972. By 1973, it produced 101 MMcfd from three wells; its reserves are estimated at 1.1 Tcf, and further development of the field is underway (O&GA, 1973). Employment at Norman Wells varies from 30 men in winter to 60 in summer (Sect. 14.c.3.8.2), while at Pointed Mountain rotating crews totalling 12 men are required to operate the gas plant complex (Scott, 1973).

Native people recently have taken jobs in the industry on a seasonal or casual basis. During the 1971-72 fiscal year such jobs provided employment for 430 individuals, and in 1972-73, for 656 people. These people were hired in various skill categories: 3 per cent filled skilled jobs; 35 per cent were semi-skilled workers; and 62 per cent were labourers. Most employment was concentrated in the Lower Mackenzie/Delta region. There is some question, however, about the degree to which Native people have adjusted to employment in the oil and gas industry. For example, one source indicates that 45 per cent of the Native

people hired by petroleum companies during the fiscal year 1971-72 terminated their employment before the end of their jobs; of these, 80 per cent were said to have resigned voluntarily. By 1973, there was some improvement in the tendency to stay with the job, but this was hardly significant (Conway, 1974. How the tenure of Native workers compares with that of non-Native workers in similar jobs is not known, and care should be exercised in interpreting information such as the foregoing.

Generally, the oil and gas industry has been a major force in the growth of the economy of the Study Region. Many other activities that have located in the region, including several government functions, probably would not exist in the region if it were not for the activities of the petroleum industry, particularly the exploration for new reserves. Yet there are some limitations to the oil and gas industry's ability to generate regional employment and growth. Its highly technical nature requires that employees normally must have training well beyond that attained by most regional residents, and that logistic support must typically by-pass northern communities and be maintained directly with southern centres where support activities are domiciled. As well, the industry is highly capital intensive, and the number of people it can efficiently employ is small in comparison with other activities. However, given the small size of the northern labour force, such factors would not seriously limit the employment impact that the industry may have.

Impact of the Pipeline

Issues

The following are of particular importance with respect to the topic:

(i) the general effect of pipeline-induced changes in the level of petroleum exploration, development, and production in the regional economy;

(ii) the more direct effect of the pipeline on regional employment in the petroleum industry.

Applicant's Statement

The Applicant states that the exploration for oil and gas would decline in the absence of a pipeline (Sect. 14.c.3.8.2). On the other hand, given the pipeline, there is little doubt that exploration would increase, particularly in the Lower Mackenzie/Delta Sub-region (Sect. 14.c.4.1.2). Development of gas reserves in the Mackenzie Delta would follow directly from construction of the pipeline.

Because these levels of exploration cannot be estimated with any accuracy, the Applicant has conservatively assumed that regional employment in exploration would remain stable at 762 man-years between 1975 and 1985 (Sect. 14.c.4.8.1 and Table 4.5). However, he expects employment man-years in natural gas development and production to increase from 600 man-years in 1975 to a peak of 1,730 in 1978 and then return to a stable level of 660 man-years in 1982, which marks the beginning of full-scale pipeline operation and natural gas production (Sect. 14.c, Table 4.5).

Commentary

It would be difficult to contest the view that a favourable decision on a natural gas pipeline would accelerate oil and gas exploration and development and that a negative decision on the Applicant's line, or any alternative that may be proposed, would significantly retard such activity. Given the prominence of the industry in the regional economy, a significant change in oil and gas activity could have a major impact on the growth of the Study Region, particularly the Lower Mackenzie/Delta Sub-

region. A negative decision on the pipeline would be felt strongly particularly by firms that provide services directly to the petroleum industry. Native people who have come to depend upon seasonal and casual employment in exploration also would be affected. Sub-regions other than the Lower Mackenzie/Delta would be affected to a somewhat lesser extent because they are less dependent on oil and gas expenditures.

According to one source, construction of the proposed pipeline could increase regional exploration and drilling expenditures from their 1973 level of $250 million to over $1 billion by the late 1970's (O&GA, 1973). Most of the increased activity and expenditures would occur in the Lower Mackenzie/Delta Sub-region. Gemini North has estimated that exploration and development activities in this region would rise from a level of 330 man-years of employment in 1973 to a peak of 1,495 man-years in 1978; thereafter it would fall to less than half of the peak level by the mid-1980's. In other Sub-regions where Gemini North assumes no gas production will take place until after the mid-1980's, employment in exploration would decrease from 434 to 372 man-years between 1973 and 1978, and then rise to a stable level of 662 during the 1980's (Gemini North, 1974, Vol. IV).

According to the Applicant, the development of regional natural gas reserves feeding into the pipeline would be the major source of employment arising directly out of the proposed pipeline, accounting for about 31 per cent of all man-years associated with the pipeline between 1975 and 1985 (Sect. 14.c, Tables 4.5 and 4.7) Activities associated with gas production would occur mainly between 1976 and 1979. Predominant among these would be plant construction, assembling the gathering system, and development drilling.

With respect to natural gas production, Gemini North estimates that man-years of employment would rise from 45 in 1974 to a stable level of 700 by 1982. This would include both employment at well site (300 man-years) and other production-related jobs located mainly at Inuvik (400 man-years). The latter would include laboratory services, administration, jobs with supply companies, special maintenance activities, communications, and government administration (Gemini North, 1974, Vol. III). These employment estimates, however, may be somewhat high. Gemini North has assumed that crews of 100 men would be required to operate each of these production plants. Another recent study of employment related to gas production indicates that between 50 and 70 men would be sufficient to man the type of gas plant that might be built in the Delta (De Pape, 1973). Furthermore, it is possible that only two plants will be built in the Delta instead of three, as assumed by Gemini North.

There will be some increased employment in a variety of activities in parts of the Study Region other than the Lower Mackenzie/Delta Sub-region once the pipeline is built. The pipeline is expected to encourage exploration throughout the entire Study Region, but the magnitude and location of this would be difficult to predict.

Increased oil and natural gas activities could amplify the seasonal employment cycle characteristic of the Study Region, which already would be greatly accentuated by pipeline construction. Pipeline construction will be concentrated in the winter months, which is also the favoured period for oil and gas exploration and development. Thus, seasonal employment in the petroleum industry likely would be superimposed upon pipeline employment, leading to an extreme "peaked" nature in the annual demand for labour.

As another consideration, building the pipeline will require a burst of intensive activity that will only last for about three to four years. Unless alternative sources of employment and revenue emerge following this period the economy of the Study Region could fall into a pronounced slump. As it is, there likely will be a build-up of gas exploration and development during the period, and the petroleum industry should be in a position to absorb a considerable part of the labour released by the pipeline as the latter moves towards operation.

Highlights

1. The oil and natural gas industry plays a very prominent role in the economy of the Study Region and appears to have provided the major impetus for recent growth in the region.

2. A decision to not construct the Applicant's pipeline, or any alternative that may be proposed, could significantly retard the exploration for natural gas, and, certainly, the development of present reserves. A favourable decision probably would accelerate regional petroleum activity.

3. If the proposed pipeline were built, a substantial number of employment man-years would become available in a wide variety of activities associated with the petroleum industry. Many of these probably would be available to regional residents.

4. Peak winter activity in heightened oil and natural gas development would be superimposed on already highly "peaked" pipeline construction, making employment in the Study Region extremely variable during the construction phase.

5. Development of the petroleum industry, which should grow rapidly during pipeline construction, probably would serve to cushion regional unemployment arising from the release of labour as construction of the pipeline moved to completion.

4.4 MINING

Background

Resource income in the Canadian North until recently was derived exclusively from renewable resources; since the discovery of minerals in the Great Bear and Great Slave Lake areas in the 1930's, non-renewable resources have become increasingly important as a source of revenue. Mining now plays a large role in the private sector of the economy of the Study Region and of the Northern Territories.

At present, six mines in each of the territories produce a variety of metals including zinc, lead, gold, silver, and copper. In 1973, the value of mine products from the Yukon Territory was $145.6 million and from the Northwest Territories, $164.8 million, a total of $310.4 million. Mining follows oil and gas in terms of private investment expenditures in the territories (M&MA, 1973, p.39). For example, in 1971, capital spending on mining was $43.3 million or 21 per cent of the $210-million total capital expenditures in the territories (Palmer, 1974, Table 9B). Although mining in the Northwest Territories is of limited national importance, it is of considerable importance regionally. (NWT Statistical Abstract, 1973, Table 50, p.74).

Within the Study Region there are producing mines at only two locations, Yellowknife and Pine Point, both of which lie well away from the Prime Route of the pipeline. Much of the Study Region consists of sedimentary rock formations, with extremely limited metallic minerals occurrence. Save for gravel sites used as sources of borrow material for roads and airstrips, non-metallic minerals virtually have not been developed to date.

Large metallic mineral reserves have been delineated in the Canadian Shield and Cordilleran Regions which lie east and west of the Mackenzie River Valley. In 1971, it was estimated that producing mines held reserves worth $4 billion, while other reserves of more than $25 billion were known but not yet developed (Hornal and Craig, 1971).

In 1973 northern mines employed 1,155 workers in the Yukon Territory and 1,344 in the Northwest Territories (M&MA, 1973). In addition, there were about 200 crews active in exploration and development in the Northwest Territories at any given time, with 10 to 15 of these crews working in the Mackenzie Valley. Exploration activities provided some seasonal employment to residents of the Study Region (R.W. Hornal, NWT, pers. comm., 1974). Mining exploration, however, is a highly volatile and mobile activity subject to fluctuations in response to external influences; employment fluctuates accordingly.

At present, all minerals produced in the Study Region are shipped south as concentrates; there is no secondary or tertiary processing. Studies of possible smelter development within the region, for example at Pine Point, have suggested that such developments might be feasible under certain favourable circumstances (Canadian Bechtel Ltd., Feasibility Study, 1968).

Impact of the Pipeline

Issues

The following are particularly important with regard to mining:

(i) the possible use of natural gas energy within the mining industry;

(ii) the effects of a pipeline on mining exploration and development;

(iii) the effects of a pipeline on labour and production costs in the mining industry.

Applicant's Statement

The Applicant comments little about the impact of the pipeline on the mining industry. He indicates that mining development plans for the 1975 to 1985 period have not yet been announced, and suggests that the increased income and employment that the pipeline could induce with respect to mineral development must remain undefined (Sect. 14.c, p.18).

Commentary

It is uncertain whether the mining industry could benefit directly from the availability of natural gas energy. A market must be of substantial size to make natural gas competitive with other energy sources. Studies made for Hay River, which is located near the Pine Point mine, and Yellowknife, where there are two producing gold mines, indicate that hydroelectric power, if available, would seem to have significant cost advantage (Underwood, McLellan & Assoc. Ltd., 1974). These studies, however, did not take specific account of the energy requirements of mining, and did not examine the question of thermal generation of electricity.

Further studies would be needed to determine whether extension of a possible Hay River trunk gas main to the Pine Point mine and townsite would increase volumes sufficiently to offset high transmission costs and thus make gas competitive with hydroelectric or other available power. Similar studies would be required to establish relative costs in an energy market which included the Con-Rycon and Giant Yellowknife mines and the communities of Yellowknife and Rae-Edzo. Owing to distance from the pipeline, other producing mines in the Northern Territories probably could not benefit from the availability of gas energy.

Development of new producing mines in the area west of the pipeline, from approximately Wrigley to Fort Simpson, and within 100 miles of the pipeline, could be influenced by the availability of natural gas. Any cost advantages over other sources of fuel would depend on volumes and transmission distances.

Construction of a lead-zinc smelter in the Hay River-Pine Point area perhaps could be feasible if low-cost fuel were available. If a sufficiently large volume of gas were required by mines, communities, and other industries in this area, the unit cost of natural gas as an energy source could be decreased significantly in comparison with available energy costs. Production of foam insulation, using the sulphur by-product of such a smelter, could again increase natural gas volume required and thus lower unit costs. However, no adequate studies have been made of these possibilities, and of other factors such as the potentials of the regional ore reserves and level of transportation costs, all of which would have a major bearing on any decision to construct a smelter.

Some reduction in the costs of finding and developing new ore bodies possibly could result from activities associated with the proposed pipeline. Construction of new access roads and landing strips, the completion of highways and general improvements in all transportation facilities and services could assist mining activity, especially west of Wrigley and Fort Simpson. Centres such as Fort Simpson and Norman Wells should develop additional facilities and services due to the pipeline, which could assist them in becoming major supply centres

for mining exploration and development. Terms and conditions concerning access to facilities constructed by the Applicant for his own use can be considered in arrangements made between the government of Canada and the Applicant concerning construction of such facilities on Crown land.

Some concern has been indicated by mining companies in the Study Region as to the effect of the pipeline on the availability of labour. There is a possibility that, if high wages are available on the pipeline project, there may be an increase in labour turnover at the mines. Alternatively, in order to retain mine personnel, labour costs may rise. This also could be accompanied by an increase in the costs of supply and transport. These cost increases could have some effect on the competitive position of mines in the Study Region.

Highlights

1. The use of natural gas in the mining industry in the Study Region may have some future potential but further studies are required as to its economic feasibility. The size of the local market for natural gas and distance from the pipeline would be major factors governing feasibility.

2. Improved and increased transportation and communications facilities induced by the pipeline could be beneficial to mining exploration and development.

3. Increases in wage rates and other costs may affect labour turnover rates at producing mines and affect their competitive position.

4.5 TOURISM

Background

The Canadians are only now becoming aware of the potential that their Northlands hold for outdoor recreation and tourism. Until quite recently, the Northern Territories were considered remote, isolated and mysterious. Now highway travel is commonplace to much of the Yukon Territory and the more southerly parts of the Study Region. Considerable attention has recently been given to building up the base on which tourism depends. National parks have been created and steps have been taken to protect and preserve natural features and landscapes. There has been a significant improvement in both the quantity and quality of northern tourist establishments.

Tourism has been an important industry in the Yukon for much longer than in the Northwest Territories. There are several reasons for this. First, much of the traffic between Alaska and the continental United States moves along the Alaska Highway and the Haines Road, both of which traverse the Yukon, and travellers typically stop en route. Second, the Yukon has a long and colourful history and is scenically spectacular in areas that are easily accessible. Third, the region has been actively promoted for some time. It has been advertised as being part of a common tourist area which includes Alaska and northern British Columbia, and it is quite easy to include the territory on "circle tours" which involve all three regions. In the Northwest Territories, tourism has been given strong promotion during only the past six or seven years. Only the relatively less scenic southern parts of the Study Region are accessible by road. Though the territories contain some of Canada's grandest scenery, much of it is remote and inaccessible to most tourists.

In both the Yukon Territory and the Northwest Territories only the more southerly regions have been actively involved in the tourist trade. In each case, highway access has played the major role.

The Government of the Yukon Territory reports that during 1972 some 200,000 tourists and some 70,000 "non-tourists" visited the Yukon. These people were estimated to have spent almost $21.8 million on transportation, accommodation and other local purchases. Yukon tourism has reportedly grown at a rate of 20 per cent per year during the 1962-72 decade. Non-tourist visitors are said to have increased at a rate of close to 14 per cent.

The Tourist Division of the Government of the Northwest Territories has estimated that 23,000 tourists visited the Northwest Territories in 1973 and spent some $6 million in the region. Of the total number, approximately 13,000 arrived by road, and would therefore have visited the southern part of the Study Region.

Of the tourists who visited the Northwest Territories in 1973, approximately 4,700 spent some $2.5 million for sports fishing and hunting ("The Travel Industry in the Northwest Territories", 1974, Govt. N.W.T.). The main species of fish caught were trout, grayling, pike, pickerel and arctic char, while the popular big-game species among hunters were buffalo, Dall's sheep, grizzlies, caribou, moose, wolf and goat. In 1973, there were 25 fishing lodges in operation in the Study Region, fourteen of them near Great Slave Lake; there were also 10 fishing outfitters and 9 big-game outfitters in the Region ("Explorers' Guide, Canada's North", 1974 Govt. N.W.T.).

Impact of the Pipeline

Issues

The following are particularly important with regard to this topic:

(i) the effect of the pipeline on the basic scenic resources of the tourist industry;

(ii) the effect of a pipeline-induced influx of transient personnel on available tourist accommodation;

(iii) the effect of the pipeline on the growth of tourism and related activities such as sports hunting and fishing in the Study Region.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" (Guideline 7) has provided a basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant does not give significant consideration to the impact of the proposed pipeline on the tourist industry *per se*, although there are references in many parts of the Application to its impact on the natural environment of the Study Region.

Commentary

When viewed from the ground, the pipeline, once built, will be a low-profile facility without much visual impact on the tourist. However, there are a variety of concerns relating to impacts of the pipeline on recreational and visual values that are discussed in this report under the titles "Aesthetics" and "Recreation, Parks and Land Reserves".

Regarding pressures on tourist accommodation and facilities, the Applicant has indicated that he will not unduly burden accommodation and other services in northern communities (Sect.14.c, p.37). This would presumably include services used by tourists. Though much of the Applicant's activity will be confined to camps during pipeline construction, some strain on accommodation and other services normally used by tourists may occur as a result of personnel movements associated with the pipeline. Activities such as the development of Mackenzie Delta gas reserves will also result in substantial personnel movements and increased accommodation requirements. However, most such movements will take place in winter, whereas the main tourist season is in summer.

The governments of both territories are attempting to meet the future requirements of the tourist industries by providing support such as staff training, promotion and the construction of facilities. Loans and grants are available from several sources. Such programs should have some effect on alleviating pressures which activities that cater to tourists may experience during pipeline construction.

Gemini North suggests that the proposed natural gas pipeline could induce a major growth of northern tourism because it would lead to a greater exposure of northern scenic resources to the southern tourist public, and because it could lead to considerable improvements in the infrastructure (roads, accommodation, communications, etc.) on which tourism depends (Gemini North, Vol. 4, Ch. V, pp.269-270). To the extent that this will be true, it is also probable that there will be an expansion of activities associated with sports fishing and hunting, including increased opportunities for those employed as guides and those who operate

fishing and big-game lodges and outfitting facilities. On the negative side however, the possibility exists that increased sports fishing and big game hunting could deplete Study Region resources.

Highlights

1. During pipeline construction, traffic due to the pipeline and associated activities is likely to place a strain on other services normally used by tourists.

2. The pipeline could induce long-term growth of tourism in the Study Region, as well as activities such as hunting and fishing.

4.6 COMMERCIAL FISHING

Background

Commercial fishing in the Study Region began in 1945 with production of approximately 1.6 million pounds of fish out of an established annual quota of 9 million pounds. The fishing operations were, as they are today, centred largely on Great Slave Lake, with a few smaller lakes (e.g. Kakisa Lake, Lac la Martre and Tathlina Lake) contributing small production.

Commercial production is made up mostly of whitefish and trout, and as much as 85 per cent of the total annual freshwater catch is sold in U.S. markets, while the remainder is earmarked for markets in the Canadian provinces and Europe. The only fishery oriented to a local market in the Study Region is the Holmes Creek operation (Mackenzie River, East Channel) whose production is sold in the Lower Mackenzie/Delta Sub-region, mainly in Inuvik. All other commercial production is sold to the Freshwater Fish Marketing Corporation in Hay River. The fish are filleted, frozen, iced and packed in the Hay River plant, transported by truck or rail to Edmonton where they are re-iced or reloaded, and then taken by truck to Winnipeg where they are stored or distributed to marketing agents.

The commercial fisheries of the whole of the Northwest Territories, which includes some minor coastal fishing as well as the inland fishery of the Mackenzie Valley, achieved a peak production level of 9.4 million pounds in 1949. However, annual production has declined steadily since then. Approximately 6.9 million pounds of fish were harvested in 1954; by 1964, production had decreased to approximately 6 million pounds, and to 2.8 million pounds during the 1973-74 season, when the established quota was 4 million pounds (Stat. Can., Fishery Statistics, Cat. #24-207; Dept. Environment computer print-out; Freshwater Fish Marketing Corpn. annual reports).

According to officials of the Freshwater Fish Marketing Corpn. and the Dept. Indian Affairs and Northern Development, there are several reasons for the decline in northern commercial fishing. One of them is that northern fishing is an arduous and uncertain business and the number of fishermen has decreased significantly with the advent of a greater range of job opportunities in the Great Slave Lake area. For example, there were 438 licensed fishermen in the Study Region in 1964, but only 289 in the 1972-73 fishing season (Dept. Environment, computer print-out). Another reason is that some fishermen have elected to fish only in the summer months. Moreover a number have curtailed their activities because of disputes with the Freshwater Fish Marketing Corpn. over prices paid for fish, which had apparently not kept pace with production costs experienced by fishermen. Production by Native fishermen has fallen significantly since the 1960's. Recently about 80 per cent of the annual catch has been harvested by non-Natives even though they comprise only 20 per cent of the licensed fishermen in the Study Region.

In addition to the difficulties mentioned above, commercial fishing in the Study Region has had to compete with domestic and sports fishing, and this has resulted in a lowering of quotas available to commercial fishermen. Quotas have also been lowered in response to the decreasing productivity of some lakes, and such measures have sometimes resulted in the cessation of commercial fishing activities. An example of this is the fishery at Lac la Martre which was closed down at the end of the 1973 season when the quota for the lake was lowered.

The growth of the industry is also inhibited by the presence of marginal fishermen who share revenue from the industry with the more efficient fishermen, and who prevent the latter from receiving enough revenue to upgrade and modernize their operations. However, for a variety of reasons, including the difficulty that some of these people would have in finding alternative employment, authorities have been able to do little to reduce the number of less efficient producers in the fishery.

Impact of the Pipeline

Issues

The following are particularly important to this topic:

(i) the effect that the pipeline might have on commercial fishing areas and on the fishery resource;

(ii) the effect of pipeline construction in providing wage employment as an alternative to employment in the commercial fishing industry;

(iii) the long-term effect of the pipeline on the commercial fishing industry.

The "Expanded Guidelines for Northern Pipelines" contain references to these issues (Social Guidelines 1, 2 and 5), and this has provided a basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant states that resource and market constraints limit the ability of the commercial fishing industry of the Study Region to expand to a size at which it would have a significant impact on employment and income in the Study Region (Sect. 14.c, p.18).

Commentary

Few resource conflicts are expected to arise from commercial fishing and pipeline development activities. Except for the small fishery at Holmes Creek, the pipeline right-of-way will be well removed from the commercial fishing grounds. However, there are a number of ways in which pipeline construction might affect the industry.

The winter fishing season, which accounts for about a third of the annual catch would coincide with peak seasonal construction on the pipeline. The commercial fishing industry is already experiencing problems in finding and retaining hired help for its winter operations, and pipeline construction could aggravate this by offering more attractive employment to northern labour. Because winter fishing operations are already caught in a severe squeeze between revenues and rising costs, operators would find it very difficult to raise their wages to levels competitive with the pipeline. Moreover, with increased employment opportunities resulting from activities such as the shipment of pipeline material, the commercial fishing industry might also be faced with a shortage of labour during the summer, especially since a large number of those engaged in fishing come from Hay River, the main transportation centre of the Study Region.

On the beneficial side, pipeline construction could ease the pressure on the fishery resource by reducing the number of marginal fishermen, so that, following an initial period of adjustment, competent fishermen could upgrade their operations through investment in modern equipment. Pipeline-related development could also enhance the growth of the commercial fishing industry of the Study Region through inducing an expansion of the local market for fishery products.

Highlights

1. Commercial fishing in the Study Region, which is centred mainly on Great Slave Lake, has undergone a marked decline in volume of output since the late 1940's. There are currently too many producers in the field, and average returns are low. Most fishermen are Native people; but the large bulk of the catch is taken by non-Natives.

2. Few resource conflicts are expected to arise from commercial fishing and pipeline development activities.

3. Pipeline development will very likely compete with the commercial fishing industry for the use of labour resources. Commercial fishermen, who are already caught in a cost-price squeeze, would find it most difficult to compete with wages paid on the pipeline, and there would probably be a loss of labour from the fishing industry.

4. A long-term result of the pipeline could be an economically more sound commercial fishing industry in the Study Region. On the one hand, the regional market for fish products could grow with pipeline-induced population growth. On the other hand, many less efficient fishermen, once drawn out of the industry and into more remunerative employment, would probably not return to fishing. This could improve the economic position of the more competent fishermen, providing them with a greater incentive to remain in production.

4.7 FOREST INDUSTRIES

Background

The forest resources of the Study Region are confined to three main areas, namely, the Hay River-Fort Smith area, the Mackenzie Valley and Delta area, and the Liard River area, with the latter containing the most valuable timber of the Region.

In the Northwest Territories, the tree line extends from northwest to southeast, from the Mackenzie Delta to the Manitoba border at Hudson Bay; it lies somewhat north of the southern limit of continuous permafrost. Type and quality of forest growth found in any locality depend on the soil base, the drainage and flood charactertistics, the presence or absence of permafrost, and climatic factors such as wind, snow cover, and temperature. These vary greatly regionally and even locally.

The more northerly part of the Mackenzie Valley, from Great Bear Lake to the Delta, is an area of continous or nearly continuous permafrost. The unfavourable climate, poor soils and frequent fires reduce the quality of regional forest growth. As a consequence, there are open stands of dwarf trees such as white birch, tamarack, aspen, and balsam poplar, with local patches containing good stands of black spruce and white spruce. There has been some use of local timber for construction of log buildings as well as the production of lumber and pilings for sale. Main centres of small-scale log and lumber production have been Fort Good Hope, Arctic Red River, and, more recently, Inuvik.

Forest stands of possible merchantable quality in the Study Region are located in the Upper and Central Mackenzie Sub-regions. There are stands of white spruce, balsam poplar, and black spruce on alluvial flats, and forests of pine, aspen, black spruce, tamarack, white birch, and white spruce on sandy benchlands. Jack pine grows on rocky hill slopes.

The average rate of tree growth is slow, especially in the lower Mackenzie River area. Some merchantable varieties of trees may require from 100 to 150 years to reach maturity. Trees of commercial size are found only within certain limited areas. Estimates have placed total merchantable timber at 14 billion cu ft, but total allowable cut has not been established. If irreparable harm is to be avoided, it is important that allowable cuts be established prior to any large-scale harvest, such as may be required for the pipeline. This is especially true for the Mackenzie Delta where forest regeneration is little understood and there is evidence that treed areas following clearing are replaced by tundra.

There are serious problems of maintaining the limited resource base. Spruce budworm has caused damage in several areas. Forest fires at times have been disastrous, particularly in view of the long regenerative period of northern forest stands.

Despite some considerable potential, the impact of forestry as an industry has been relatively insignificant in the Northwest Territories. Within the small manufacturing sector of the territories, it has accounted for approximately 25 to 30 per cent of total man-hours work and about 20 per cent of total wages and salaries paid. Yet, in over-all terms, it accounts for only 0.2 per cent of total wages and salaries in the Northern Territories. This relatively minor role is somewhat surprising in view of the fact that there has long been a strong demand for forest products in the Study Region, and the fact that there is no scarcity of forest resources. The problems facing the industry are primarily those associated with small-scale

operations, such as lack of efficient management and inefficient labour. Saw mills have received extensive subsidy from government, and virtually have never been exposed to the realities of a competitive market.

Impact of the Pipeline

Issues

The following are particularly relevant to the topic:

(i) the direct effect of pipeline construction on the forest industry;

(ii) the effect of longer term demand on the growth of the regional forest industry induced by the pipeline.

"Social Guideline" #7 of the "Expanded Guidelines for Northern Pipelines" contains references to these issues and has prompted "Requests for Supplementary Information."

Applicant's Statement

The Applicant recognizes the potential of the forest stands of the Study Region. He indicates that current actual cut is a fraction of the potential, as present milling operations are conducted well below capacity owing to constraints imposed by weather and a lack of working capital. He notes that forestry consultants indicate the possibility of an expansion of forest-related industries, and suggests that this might be based on the local manufacture of prefabricated building components. He believes, however, that even the full realization of the potential of the regional forest industry would not yield a significant increase in employment (Sect. 14.d, p.18). There is no discussion of the specific impact of the proposed pipeline on forestry.

Commentary

The construction of a pipeline and related development could require substantial quantities of unprocessed and processed lumber, estimated by the Applicant at 6 million board feet (Sect. 13.a, p.4). One independent study suggests that if all this lumber were produced in the Northwest Territories, the resulting work could employ about 15 men (Information from Resources Management Consultants Ltd.). The direct impact of the pipeline on the regional forest industry therefore would not appear to be great. However, the impact on the forests *per se* may be great. For instance, a depletion of this resource could result if substantial production of timber for the pipeline is generated in the Mackenzie Delta and the lower Mackenzie Valley.

In the longer term, however, and if planned well enough in advance, forest-based industries should be capable of expanding with the general economic and social growth of the Study Region. Increases in population and income arising in part as a result of the pipeline therefore could be matched by comparable increases in the demand for forest products. The present weak and undeveloped state of the industry, however, would impose some severe constraints on its ability to grow. Considerable thought would have to be given to the organization and management of the industry if it were to be a successful component of regional growth in the long run.

As with other local industries, the construction of the pipeline may have an additional adverse effect on the forest industry by providing alternative employment for the regional labour force.

The forestry worker, usually poorly paid and often working in isolation away from his community, could find the well-paid pipeline jobs quite attractive in comparison.

Highlights

1. Construction of the pipeline will require considerable quantities of rough lumber. If some or all of this were produced in the Study Region, a minor increase in forest industry employment would occur.

2. In the long term, the forest industry could grow with the expansion of regional activity induced, in part, by the pipeline. However, the industry might require considerable improvement in organization and management before much future growth was possible.

3. Substantial use of timber could lead to depletion of forest resources in some parts of the region, and particularly in the lower Mackenzie Valley. It is important that the allowable cut be established prior to major increases in use so as to ensure that resources be maintained for future local use.

4.8 AGRICULTURE

Background

Agriculture is not a significant economic activity in the Study Region. Production is confined mainly to the alluvial soils of the Liard, Slave, Hay and Mackenzie River valleys. Farms are small (averaging about 60 acres) and are limited to supplementing local demands for fresh produce, including vegetables, dairy products, and poultry products. Together, these farms employ about 20 persons, some of them on a part-time basis (MPS, Vol. 1, p.125).

Although experiments have demonstrated that vegetable and field crops can be grown and farm animals can be raised in the Study Region, the area is not well suited to agriculture because of such factors as a short growing season, limited precipitation, and low temperatures; poor soil condition; inaccessibility of potentially arable land; and high supply costs due to transport distances from supply sources. Additional difficulties include the poor ability to mechanize because of low income and small farm size, the limited local market and the isolation from larger markets, and the unavailability or high cost of local labour.

The foregoing suggests that farming as a commercial full-time operation in the Northern Territories can be expected to achieve only limited success, now or in the foreseeable future. It is true that some individuals who have particular capabilities, farm knowledge and experience, outside employment or assistance, as well as an ability to persist against hardship, could farm with moderate success for an indefinite period. However, it is not possible to generalize from the experience of these particular few.

The main attraction of farming in the Study Region might be the low price of land and the high price of imported agricultural produce. Yet these favourable factors are far from sufficient to overcome the major disadvantages within the region. Residents likely will confine their agricultural activities to small kitchen gardens in an attempt to offset the effects of the high cost of fresh produce.

Impact of the Pipeline

Issues

The following are particularly important to the topic:

(i) the effect the pipeline might have on the immediate market for agricultural products and hence on agriculture in the Study Region;

(ii) possible long-term effects of the pipeline on agriculture.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references to such issues (Guideline 4) and these have prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant is not optimistic about possible benefits of the proposed pipeline on the agricultural industry of the Study Region. He simply points out that development and operating costs, as well as other difficulties, have inhibited the growth of an agricultural industry in the Northwest Territories, and that, in the absence of a specific public commitment in the form of development assistance, the industry is likely to continue

to be a minor source of employment and income in the Study Region (Sect. 14.c, p.18).

Commentary

Gemini North has examined the pipeline construction program closely and has concluded that population increases in the Mackenzie Valley might lead to an increase in the demand for some agricultural products at a level that would make larger scale, more productive farming possible in the Study Region (Gemini North, Book 2, Vol. 4, Ch. II, p.15). However, this would appear to be somewhat optimistic. The increase in market size from pipeline construction will be a transitory and highly seasonal phenomenon. Under such circumstances, it is unlikely that farmers would risk expansion; indeed, they perhaps should be cautioned against doing so. Fresh foods for pipeline construction workers could most economically be supplied from outside the Northern Territories. Problems associated with storage, logistics and the continuity of supply would necessitate this.

Farm operators in the Study Region perhaps would abandon agriculture in favour of higher annual incomes provided by pipeline work. Should this become the case, the pipeline project would actually have a negative impact on the regional agricultural industry rather than provide an impetus for development.

Various unconventional agricultural schemes have been under development in recent years and some might find application in the North, given further technological development and perhaps some public-sector absorption of risks. One example is greenhousing that utilizes waste heat from facilities such as local diesel-generating plants; another is hydroponics. The potential for application of such schemes in the North cannot be evaluated from the rudimentary studies conducted to date.

Highlights

1. The pipeline is not likely to have much effect on agriculture in the Study Region. Produce probably will be moved in from the South much more economically than it could be grown in the region.

2. In the long term, the effect of the pipeline on regional agriculture could be negative since it could increasingly draw labour from agriculture into more remunerative employment.

3. Based on present data, no conclusions can be drawn about the possible application of unconventional agricultural techniques such as greenhousing and hydroponics.

4.9 TRANSPORTATION

Background

This section is concerned with the current and emerging transportation system that is being established to serve all the varied purposes of the Study Region. Transportation support that will be developed specifically for the pipeline is included in the discussion, but only insofar as it affects the long-term development of transport capacity. The section is not concerned with an examination of the proposed pipeline as a specialized transport mode.

All four main methods of transportation, that is, water, rail, road and air operate in the Study Region. Barge transport continues to be the mainstay of the regional freight transportation. The all-weather road system that connects the region with the South via the Mackenzie Highway thus far extends only as far as Fort Simpson. The single railroad, the Great Slave Lake Railway, links the Study Region with the continental rail system, but terminates at Hay River. In recent years, railway and road transport have tended to complement the river tug and barge system, although trucking has become increasingly competitive with the river system for some commodities. Such competition has reached northward to areas beyond the permanent road system by means of winter roads. Most passenger movements, to and within the Study Region, rely on air transport. The regional system of airports is extensive and well developed.

Historically, the Athabasca, Slave and Mackenzie rivers provided a natural route that filled many of the major transportation needs of the Mackenzie District. Vessels operating between the Mackenzie Delta and the Boothia Peninsula extended this system to several communities and DEW-line stations along the Arctic Coast. While its more southerly parts have been displaced by the Great Slave Lake Railway, the river system downstream from Hay River remains an important route, particularly for cargoes such as construction materials, heavy equipment and bulk fuel.

North of Fort Simpson, where the all-weather highway system now terminates, surface transport consists almost entirely of river barge service, which enjoys a competitive advantage over air service, the main alternative, and the only means of year-round transport through the Study Region. While air transport cannot compete with barge service in handling bulk freight because of substantially higher costs, it is the main means of transporting high-value commodities, including perishables.

With respect to traffic volumes, Northern Transportation Company Limited and other water carriers hauled a total of 402,777 tons of freight in 1973 (Water Transport Committee-CTC). Of this, 343,238 tons moved north while only 59,539 tons moved south. The Great Slave Lake Railway delivered 108,000 tons of bulk products and 65,000 tons of general freight to barge companies operating out of Hay River for shipment north in 1972. In the same year, an estimated 108,000 tons of highway freight were delivered to clients in the Mackenzie Valley area by common, contract and supplier-owned carriers (Podmore, 1974). Air freight volumes are not significant in comparison with those of surface modes. However, in terms of passenger traffic, the six most important commercial airlines serving the Northwest Territories from southern Canada and the Yukon reported carrying 77,800 passengers to the Northwest Territories in 1973 ("Travel Industry", Govt. of NWT). Most of these people would have moved between Edmonton and destinations in the Study Region.

All modes of transport in the Study Region are affected by high costs and this is reflected in their tariffs. High costs derive from a number of causes. While transport volumes have been growing, they are still quite small and few economies of scale can be achieved. With the exception of bulk minerals moving south in quantity from Pine Point, traffic is largely one-directional northbound, and vehicles are only partially loaded southbound. Because of the severe climate and the limited development of all-weather facilities, seasonal transportation is a dominant part of the over-all system. The costs of capacity used during only the brief summer must be carried the year round, and are typically passed on to users. Climatic and geographic factors combine to make the Study Region a difficult and costly place in which to build transportation facilities. Eventually, with the growth of activity and traffic, transportation costs should fall. However, no major breakthroughs should be expected for some considerable time.

Impact of the Pipeline

Issues

The following are particularly important with respect to transportation:

(i) the effect of pipeline and related traffic on the capacity of the regional transport system during the construction phase;

(ii) the effect of the pipeline on transport user charges;

(iii) the effect of the pipeline on employment in regional transportation industries;

(iv) the long-term effect on regional development of facilities such as roads, docks, airstrips, which will be built or improved in connection with the pipeline.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" (particularly Guidelines 7 and 8) have prompted questions embodied in "Requests for Supplementary Information".

Applicant's Statement

The Applicant has indicated that at least eight new 4,500-hp tugs and forty-eight 1500-series barges will be required to transport about 1.5 million tons of material and equipment to stockpiles north of Fort Simpson. Truck and rail will be used jointly to carry supplies and equipment to stockpiles between Fort Simpson and the 49th parallel. The Applicant does not intend to use trucks for the transportation of significant volumes of supplies to stockpiles north of Fort Simpson where, in his opinion, the Mackenzie River tug and barge system can provide transportation more economically (Section 13.a.3.3 and 3.4). However, trucks will of course play a major role in local transport along the pipeline right-of-way.

The Applicant indicates that during the four peak years of pipeline activity (1976 to 1979 inclusive), 2,200 man-years of employment would be generated in the transportation sector because of pipeline construction. Well over half of this would occur in water transport (Section 14.c, Table 4.5).

Actions taken by the Applicant will have an effect on access to small communities. As one example, several docks, wharves and small airstrips will be built or improved. Where this is practical and desirable, the Applicant intends to make these facilities available to the local community when

he no longer requires them, and account will therefore be taken of local needs in design. A similar intention is stated with respect to new and improved airstrips (Section 14.c, pp.38 and 39).

Commentary

Construction of the proposed pipeline could impose a heavy burden on transportation capacity throughout the Study Region. Extensive additions to facilities and equipment will be needed to enable the transportation of some 1.5 million tons of pipe, supplies and construction equipment in a three-year period. The additions to regional transport capacity indicated by the Applicant may be sufficient to meet his specific requirements, but there is no indication that any consideration has been given to the needs of pipeline-related activities such as the development of the Mackenzie Delta gas-gathering system. Unless these needs are taken into account, severe shortages of capacity could at some stage result.

Many of the additional trucks, railway cars and aircraft that will be required for pipeline construction are standard equipment that can be leased or purchased, and can probably find uses elsewhere following pipeline construction. However, tugs and barges used on the Mackenzie River are mostly custom-made for shallow-draft operations and cannot be easily adapted to other waterways. To avoid sustaining heavy losses resulting from redundant capacity, barging companies may have to recover the capital costs of equipment expansions made to accommodate pipeline traffic during the construction period. This could significantly increase transport rates, perhaps resulting in large diversions of traffic to trucking in the case of points that could be reached by highway. All groups in the Study Region could be affected by these higher costs and traffic diversions, including consumers in Mackenzie River communities. One way of avoiding such a situation would be to ensure that the Applicant bear the full costs of transport provided especially for his purposes.

An early decision is required on how the expanded capacity needs of the Applicant are to be met and financed because of the long lead-time needed to order and build transport equipment. Unless barging companies are given early assurances that they will be able to recover the extra costs they will incur in pipeline haulage, sufficient equipment might not be available for the large pipeline stockpiling program. As for other modes of transport, care should now be taken to ensure that sufficient capacity will be available, because national shortages of equipment, such as railway cars, have emerged in recent years.

Regulatory authorities should ensure that discriminatory pricing which favours the Applicant, and which in effect could lead to situations in which ordinary users subsidize pipeline traffic, is not practiced with respect to any transport mode. Competing transportation companies could attempt to use such practices while bidding on specific haulage contracts.

A number of independent studies agree that the extension of the Mackenzie Highway north of Fort Simpson will result in a diversion of some traffic from the river-barging mode to trucking. If the costs of the pipeline-related capacity requirements were built into the tug and barge rate structure, such diversions could become large, affecting a wide spectrum of commodities. As has already been indicated, transport costs to all Mackenzie Valley users could rise under such circumstances (see, for example, MPS, Vol. 3, 1972 and Travacon, Vol. 1, 1972).

Pipeline traffic will likely represent only a very

small fraction of total Canadian rail traffic and is expected to have little effect on the continental rail system. However, there would be a substantial impact on the Northern Alberta Railway and Great Slave Lake Railway, and these companies would probably require additions to sidings and terminals on their northern sections.

The pipeline project could place some strain on both scheduled and charter air passenger services, particularly at the beginning and end of each construction season, and at peak holiday periods, such as Christmas. Crew rotation could provide a continuous source of relatively high traffic volume, although the Applicant may provide the necessary capacity himself by leasing or chartering aircraft. Air transport will also be used for purposes such as the transportation of perishable food and emergency spare parts, in order to avoid delays in pipeline construction schedules. All such things considered, contribution of the pipeline could lead to some growth of regional and local air services. Again, care would have to be taken to prevent a situation of post-construction excess capacity from developing (Sect. 13.a.3.2, p.15).

The number of jobs that pipeline transportation will create will probably be higher than figures indicated by the Applicant, which do not include an estimate of the jobs that will be created in the labour-intensive trucking industry. The employment effect of trucking would of course be of particular significance if substantial use of this mode occurred north of Fort Simpson (MPS, Vol. 3, 1973).

In addition to the foregoing, the pipeline could have a variety of long-term effects on transportation in the Study Region, for example, an intermodal shift of traffic toward trucking. More likely than this, however, is that pressures will be created on existing transport centres such as Hay River and Inuvik, with a resultant large increase in their capacity to handle freight. Again, redundant capacity following the pipeline should be of concern. Fort Simpson, favourably located as to both water and road transport, could become a trans-shipment point of increasing importance. A substantial number of docks, airstrips and local roads will be constructed or upgraded as a result of the pipeline, and these could be of benefit to local communities. Such facilities could also be important to mineral exploration, provided of course that they are maintained following the completion of the pipeline.

Highlights

1. Construction of the proposed pipeline will require a large increase in regional transport capacities, particularly barge capacity. Additional requirements, which do not seem to have been taken into account in the Application, will be posed by activities such as construction of the Mackenzie Delta gas-gathering system.

2. That much of the capacity provided for the pipeline could become excess to regional needs following pipeline construction must always be borne in mind when decisions are being made about such capacity. The question of how redundant capacity will be disposed of is an important one as it could have a bearing on long-term transport costs in the Study Region.

3. A decision is required on the financing of the additional capacity required by the pipeline. If recovery of costs were to take place via the common carrier rate structure, user charges along the Mackenzie Valley could increase to a point at which trucking would become competitive with barge transport. Large diversions of traffic could result, particularly if points north of

Fort Simpson had become accessible by road. The principle that the Applicant should fully pay for all transport requirements arising directly out of the pipeline construction schedule should be considered.

4. Decisions on capacity requirements and financing are needed because of the long lead-time required for the construction of vehicles such as tugs and barges and possible shortages of other types of equipment.

5. Care should be taken to ensure that price discrimination is not practiced against ordinary users by carriers wishing to gain an advantage over competition with respect to pipeline traffic.

6. The large volume of passenger traffic and high-value freight (e.g. emergency spare parts; perishable foodstuffs) associated with the pipeline could lead to some expansion of regional air transport capacity.

7. Employment arising out of pipeline transport will be significant and could be larger than the Applicant indicates if more trucking is employed than the Applicant assumes.

8. The pipeline will have a number of long-term effects such as the growth of regional transport centres, and the construction or reconstruction of local wharves, airstrips and roads. Some of these facilities could be of benefit to activities such as mineral exploration.

4.10 COMMUNICATIONS

Background

Development of communications in the North has been hampered by a number of constraints. Vast distances, sparse population, extreme climatic conditions and high costs of equipment installation and maintenance are aggravated by the financial problems raised by an almost non-existent revenue base.

Over time, voice communications systems serving a variety of functional purposes were developed in the Mackenzie Valley and western Arctic as specific needs arose. The Hudson's Bay Company, mission groups, the RCMP, government departments and agencies, private institutions and businesses have set up individual systems to meet needs such as administration, navigation, military surveillance and resource development. Service to the region as a whole varies from fair to non-existent or inaccessible to the general public. There are gaps and duplications in the systems.

There are five main types of voice and data communications facilities currently in use in the Mackenzie Valley and western Arctic. The tropospheric scatter system of the DEW line is the only lateral transmission system in the Arctic, running from Cape Dyer in the east to Komakuk Beach in the Yukon. A line from Lady Franklin Point to Hay River, operated by the CNT, connects the DEW line to southern networks. The latter carries some commercial traffic; the former does not.

Low-frequency radio transmission is chiefly used in the Arctic by the Ministry of Transport to transmit meteorological, navigational and traffic data. High-frequency radio transmission is widely used in the North because it is relatively cheap and is adequate for non-critical operations. An open-wire landline was constructed in the early 1960's from Hay River to Inuvik and to Yellowknife, but this facility has now become obsolete and is being phased out. Micro-wave radio relay transmission is expected to carry the bulk of future trunkline traffic in the western Arctic It is relatively expensive to install but is more reliable than alternative systems and can handle a greater volume of traffic, both initially and through augmentation.

The Mackenzie Valley micro-wave system, replacing the open-wire landline from Hay River to Inuvik, has been completed from Hay River to Norman Wells and from Arctic Red River to Inuvik. Extensions from Norman Wells to Arctic Red River and from Fort Simpson to Fort Norman will be completed in 1976. The system connects at Hay River with the micro-wave trunk line to Edmonton and the tropospheric scatter system to the DEW line. There are UHF-VHF radio links to the Delta, but mainline traffic from the Delta to Yellowknife is currently routed through Whitehorse and the South (D.H. Loftus, 1970; Telecommunications, 1970).

In addition to voice and data transmission, communications facilities are used to carry radio and TV programming. Since 1972, broadcast radio has been made available to 15 communities in the Yukon and to 20 in the Northwest Territories. CBC radio programs are broadcast over local communications channels. There is some local programming using low-power radio relay transmitters.

Satellite communication in the western Arctic is presently used solely for reception of live colour TV network programs from southern networks. These have generally replaced the "packaged" TV programs formerly shipped north for local rebroadcasting. There are currently no TV programs produced in

Indian or Eskimo languages and no facilities for transmission of TV programs originating in the North. However, the CBC has developed a "Northern Broadcasting Plan" which includes provision for television programming in the Native languages.

If expansion of present programming is implemented, there may be a requirement for further circuits on available satellite channels. Existing and proposed satellite earth stations can be adapted to transmit other communications signals in addition to TV transmission (interviews and data— Telesat Canada).

Until recently, volume of traffic did not justify heavy capital expenditures on planning and construction of comprehensive common-carrier network facilities. Present developments, however, both economic and social, demand the kind of services that are available in the South. Various government agencies are planning to expand existing systems. Public needs include a sufficient number of circuits to handle present and future traffic; extension of services to communities that have inadequate facilities; complete reliability of operation and the inclusion of telex, data transmission and related services.

The Department of Communications has sponsored a Working Group to study emerging northern communications requirements of all government departments, agencies and corporations. This could provide a basis for planning an integrated common-carrier system and for phasing out most of the independent, uncoordinated systems used in the North at present.

Impact of the Pipeline

Issues

Among many possible issues, the following appear to warrant special attention with respect to the subject of communications:

(i) the effect of the pipeline-generated traffic on the capacity of the existing communications system to provide adequate service;

(ii) the optimum method for ensuring that necessary expansion of existing services is provided in order to maintain an adequate level of service to the Study Region as a whole;

(iii) options concerning ownership and operation of any new capacity provided for the Applicant's permanent requirements as they affect both short-term expansion needs and long-term improvement of communications systems in the North.

The "Social Guidleines" section of the "Expanded Guidelines for Northern Pipelines" contains references to these issues (Guideline 7) that have prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant states that he has considered three alternative types of main trunkline facilities: a micro-wave radio relay system, a co-axial cable system and a satellite system. He notes that co-axial cable systems are not now technically feasible; that some aspects and advantages of a satellite system are being investigated. He does not discuss these alternatives further however and describes only a system based on a micro-wave radio relay trunkline (Sects. 8.b.7 and 13.a.2.3.3, p.10).

He also states that his own permanent communications system will not be fully operational until

pipeline construction is completed. During the construction phase he will use existing regional public communications facilities for most of his requirements. He states that he will avoid "over-burdening" community services and will cooperate with the common-carrier in expanding existing facilities to accommodate his required services (Sect. 8.b.7.3, p.4).

The Applicant indicates that the permanent communications system required for the operations phase will need to be completely "dedicated" to the pipeline and that he will not provide any terminal facilities for community use. His permanent system will, however, require continued access to the public network through terminal facilities provided by the common carrier in the various Study Region communities. He also states that he intends to cooperate with those responsible for providing community services, but does not elaborate on this (Sect. 14.c.5).

The Application contains a brief discussion of two alternative methods of meeting the pipeline's communications requirements. The Applicant can design, build and operate his own private, wholly-owned system, completely dedicated to the service of the pipeline, or he can lease component parts of a public communications system. These components would be built and operated by the common carrier, but designed to the Applicant's specifications. The requirements of the pipeline communications system will be basically the same, regardless of which alternative is selected. The Applicant does not commit himself, by statements in the Application, to either alternative (Sect. 8.b.7, pp.2-3).

Commentary

The pipeline project will obviously create heavily increased traffic loads on the existing communications system, both indirectly and directly. Indirectly, growth in government and private activities and population increases induced by the project may double the requirements for voice circuits alone. Directly, the demands of the pipeline itself should not be underestimated. The additional traffic load that the public communications system will be required to carry will be particularly heavy during pipeline construction, before the Applicant's permanent communications system is operational.

During the construction phase, the Applicant's requirements will include: telephone service, including long distance service and pay telephones into all construction camps, for the use of crews and other personnel; data services to aid in logistics control and administration; and mobile services to provide voice communication for personnel on construction spreads, in aircraft or in boats. While the latter may be a closed-circuit VHF system with assigned circuits, the former two services will depend heavily on existing public facilities. Traffic generated by the pipeline could overburden existing communications capacity during the construction period unless there were an early expansion and upgrading of common-carrier facilities.

Although the Applicant states that he will cooperate with the common carrier in expanding existing facilities to include his local telephone service to camps and the mobile services required on the pipeline right-of-way, his only specific reference to common-carrier facilities relates to the addition of telex and other data transmission services. He makes no reference to the possible overloading of public communications circuits nor does he mention that this could require a significant expansion of common-carrier capacity, including the possible augmentation of the backbone microwave system itself.

In order to allow the common carrier to plan for the financing and construction of whatever expan-

sions may be required, it is essential that the Applicant and the common carrier should reach agreement, prior to pipeline construction on the probable volume of additional traffic to be carried by the common carrier. Any such agreement should include an understanding of the responsibility of the Applicant with respect to any expansion programs that may be needed to maintain adequate service to all users in the Study Region.

During the operations phase, the pipeline will also generate a substantial amount of traffic over the common-carrier network. The permanent system required for pipeline operation will consist of three sub-systems: a Gas Control System, a Maintenance Information System and an Integrated Communications System. The Gas Control System and the Maintenance Information System must be dedicated exclusively to pipline operation and maintenance. The Integrated Communications System will be fully integrated with the first two systems as well as with the public system. It will comprise four parts: a mobile radio system for personnel operating along the right-of-way; a pipeline party-line system for operational communications; a company automatic telephone system connecting all pipeline offices and facilities and interconnected to the public network; and a backbone micro-wave radio relay system, with associated multiplex voice and data circuits, running parallel to the length of the pipeline (Sect. 8.b.7).

With respect to alternative types of main trunkline systems, Telesat Canada is understood to have conducted some investigations of a satellite system designed to meet the Applicant's requirements (interviews—Telesat Canada). Construction and maintenance costs of the backbone system, or trunkline, represent a major part of the over-all costs of a communications system. A satellite-based system could represent some duplication of systems already planned or under construction. It could be more difficult to integrate into an over-all common-carrier system designed to serve all users, than would be the case with a micro-wave system. With either system, the Applicant would still require access to services provided by the common carrier.

The question of ownership and operation of new facilities required for the pipeline would appear to be an issue warranting serious attention. A wholly dedicated system, completely owned and operated by the Applicant, would contribute little to the revenue base of an integrated common-carrier system and would help perpetuate the existing fragmented communications system of the Study Region.

On the other hand, the facilities required for the pipeline could be designed and maintained for the Applicant by the common carrier and leased to him. Such facilities could be integrated with the common carrier's facilities and this could lead to greater efficiency and less duplication in the total regional communications system, as well as providing for better coordination of the requirements of the construction period and providing for longer term needs. The revenues derived by the common carrier under such an arrangement could contribute to the construction and operation of an expanded, integrated public carrier system serving all regional users. Moreover, the security and safety of pipeline operations would not be compromised since the specialized systems required for pipeline operation and maintenance would be reserved, during the life of the pipeline.

Highlights

1. Pipeline traffic, during both the construction and operation phase, will impose a substantial burden upon the public communication system of the Study Region.

2. With respect to minimizing adverse effects on

the public system, before construction of the pipeline begins, it would be appropriate to have an understanding between the Applicant and the common carrier on the extent to which the Applicant will require the use of existing common-carrier facilities, as well as on additional special services the Applicant may require during the construction phase and the operations phase respectively. Such an understanding could include arrangements for the sharing of responsibility for planning and costs. Unless this is done, common-carrier capacity could be overburdened by the pipeline, and the quality of communications service in the Study Region could deteriorate.

3. For operation of the pipeline, the Applicant will require construction of specialized communications facilities dedicated to his exclusive use. He will also require more general voice and data services, including access to the public system. A decision will have to be made between, on the one hand, building a distinct pipeline communications network which would include a separate backbone trunkline as well as access to the public system, and, on the other hand, providing the specialized facilities and additional capacity needed for the pipeline as part of an improved public communications system, and leasing back to the Applicant the specialized systems and reserved circuits he requires.

4. The outcome of this choice could have both short-term and long-term effects on the over-all quality of communication services in the Study Region. An integration of pipeline and public systems and facilities would seem to offer greater advantages from a public benefit point of view.

4.11 CONSTRUCTION

Background

The pipeline project will generate a great deal of employment in construction activities. Much of this will be in the form of individual employment on the pipeline itself, a topic that has been dealt with elsewhere in this report. The concern here is with the impact of the pipeline project on the construction "industry" as it exists in the Study Region.

Northern construction companies operate under a number of constraints. According to Gemini North, these include high operating costs, labour shortages and high turnover, low level of technical and managerial skills, limited access to capital or credit, unreliability of supply delivery, and a tendency by government to carry out projects itself or to award contracts to southern firms without notice to northern contractors who might wish to tender a bid (Gemini North, Vol. 4, Ch. V, p. 133). Most contracts handled are small. There has been little experience with procedures such as cooperative bidding, the formation of consortiums or equipment-leasing arrangements which are often used by smaller firms elsewhere to handle large contracts without undue expansion. Almost all building materials are imported from the South, often in the form of prefabricated units and in many cases buildings such as houses, schools and nursing stations are merely assembled in the North. Southern firms are contracted for most government and private projects.

Some general contracting firms have been established in the Study Region in response to road-building programs, as well as the requirements of mining and oil and gas industries. Outside of some trucking and haulage firms, many of these firms are northern offices for southern companies.

According to Gemini North, there are 39 construction contractors in the Study Region. Total employment with these firms is about 375 man-years annually (Gemini North, Vol. 4, Ch. V, pp. 215-217). A 1971-72 government survey found that about 40 companies in the Mackenzie District had equipment suitable for road building (Unpublished NWT Survey for Hire North, 1971-2). However, these ranged from individuals with one gravel truck to firms with more than 50 items of heavy equipment. The telephone directory relevant to the Study Region lists about 100 general and other contractors, building and sub-trades, equipment supply and related firms, many of which are small, marginal operations.

During the 1973-74 fiscal year, 560 service contracts and 89 formal contracts were let by the Department of Public Works of the Government of the Northwest Territories. Of these, only 27 were worth over $100,000; 555 were worth less than $25,000 and 57 were for $10,000 or less. Many were merely for equipment rental. The largest group of contracts was for rental housing, worth over $900,000, recently awarded to a Yellowknife construction company (Unpublished report, Dept. Public Works, Govt. Northwest Territories, 1974).

Issues

The following issues are of particular importance with respect to the construction industry:

(i) the amount of construction work on the pipeline project that will be available for contract, and the ability of local contractors to participate;

(ii) the opportunities for building and sub-trades contractors to participate in

pipeline, or pipeline-induced, construction activities;

(iii) the kind of contract opportunity likely to bring minimum disruption and maximum long-term benefit to local contractors;

(iv) the long-term effects of the pipeline on the regional construction industry.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" (particularly Guidelines 4 and 7) contains references to these issues, which have been raised in "Requests for Supplementary Information".

Applicant's Statement

The Applicant agrees in principle to design and publicize contracts and sub-contracts so as to invite and encourage bids from Native organizations, settlement councils and local contractors. However, he has two serious reservations about such a policy: first, local procurement could have adverse effects on the logistics of the pipeline project if local suppliers of goods and services were unable to meet rigid schedules. Second, if practiced indiscriminately, such purchases could lead to business expansion unrelated to the long-term economic growth of the region.

In view of the possible de-stabilizing effect of the pipeline in the regional economy, the Applicant recommends the establishment of a "Study Region Economic Liaison Group" (Sect. 14.c, p. 40) to coordinate his local purchase requirements with the capacity of the regional economy, and to ensure that local suppliers and contractors are aware of his needs (Sect. 14.c, pp.36-37).

The Applicant indicates that no local contracts will be available to building contractors for construction of camp buildings, compressor and measuring stations. Such facilities will be of standardized, prefabricated design, probably of steel construction, shipped to site, where they will be assembled and installed by experienced crews (Sect. 13.a.6.4.5. and Sect. 8.b.1.4.3 and 1.4.4).

Commentary

Construction contracts resulting from the pipeline will relate to three types of activities; primary direct construction, relating to actual construction of the pipeline and its immediate facilities; primary indirect construction, related to the supply of materials, goods and services to the project or to primary developments dependent on the project; and secondary construction arising from an induced increase in permanent population and growth of regional business activities (Sect. 14. c.4.1, p.23 and Gemini North, Vol. 3, p.2). While the reservations noted by the Applicant will apply in some degree to all contracts relating to the pipeline, they will apply most particularly to primary direct contracts.

The Applicant will have considerable influence on the awarding of contracts. Through his prime contractors, he will of course control the awarding of primary direct contracts and of some primary indirect contracts. Other contracts in the latter category will likely be sub-contracts awarded by transportation and other service and supply companies and by the contractors constructing the gas gathering system. With respect to secondary construction, the Applicant, in consultation with representatives of territorial and local authorities, will be in a position to influence the awarding of contracts for housing, recreational facilities and other projects which are provided, at least in part, for the benefit of pipeline employees and personnel.

The largest construction contracts will be those related to primary direct construction. Right-of-way and site clearance, preliminary site preparation, construction of campsites, access and material delivery facilities on each section of the route must be completed before pipeline construction begins. In addition to right-of-way and site clearance, considerable construction work could be handled by contract. As shown on the Applicant's route maps (Sect. 13.a.2.2), in the territories this will include site preparation for about 26 material stockpiles, 126 borrow pits and 27 campsites, construction of about 400 miles of all-weather and temporary access roads and winter trails, construction of 66 helipad sites and 13 new airstrips, plus upgrading of 3 or more existing airstrips* and construction or upgrading of 18 wharves.

Much of the work listed can reasonably be broken down into sub-contracts of which some could perhaps be handled by northern contractors, alone or cooperatively. Many of these contractors are experienced in general construction and some have the necessary equipment to handle fairly substantial construction jobs. However, the contracts would be large and the scheduling rigid.

A project of the size of the pipeline requires enormous amounts of capital, manpower and equipment. Delays become extremely costly, especially in the North where they are measured not merely in days lost but, quite possibly, in terms of the loss of a whole season. Logistics must be carefully planned in advance. Men, supplies and equipment must be on-site when required and completion schedules must be met. Local firms may expect to participate in the pipeline project, but only to the extent that they are able to handle the size and timing of the various contracts.

Primary indirect construction, related to the expansion of the transport and supply industries, oil and gas activities, and the establishment of the Mackenzie Delta gas gathering system, is expected to produce some local work. According to the Applicant's logistics schedules, the in-flow of pipeline materials will be seasonally scheduled to permit trans-shipment to stockpile sites with minimum delay. Nevertheless, some expansion of trans-shipment and storage facilities will be required even to accommodate the increased demand for general freight and bulk fuel for community supply, which Gemini North believes will more than double present barge tonnage by 1981 (Gemini North, Vol. 4, p.170). Railway storage, truck warehousing, maintenance and repair, barge construction and repair and commodity storage will require new facilities. Airport hangars and maintenance buildings will be required, as well as accommodation at staging airports for construction crews and other personnel in transit to and from camps. Construction of the Mackenzie Delta gas gathering system may provide some contracts for site pads and access roads. However, building units will normally be standardized units prefabricated in the south (DePape, 1973).

Secondary construction activities will arise from demands for housing, school and hospital accommodation, recreation facilities, municipal services and public utilities, new office buildings and other facilities. There will be many opportunities available to local firms.

* Number of new and existing airstrips shown on route maps (Sect. 13.a.2.2) does not correspond with numbers given in text (Sect. 13.a.1.1, Introduction, p.1), which states that, in all of Canada, 21 airstrips will be installed and a further three existing airstrips will be upgraded.

The Applicant suggests that there will be little population impact on Study Region communities during the pipeline construction phase. However, it is realistic to expect that the construction phase will stimulate the expansion of several community-based activities. Increases in regional per capita income will lead to demand for more goods and services. Although construction workers will be accommodated at camps along the right-of-way, there will be some in-migration of pipeline personnel, government staff and prospective entrepreneurs even during pipeline construction. There will probably be some movement of local population to main communities.

Growth will be most rapid at the Applicant's district centres of Fort Simpson, Norman Wells and, especially, Inuvik, which will also be a regional headquarters for the pipeline and a centre for oil and gas development. Main impact communities will require more and better housing, increased hospital and school accommodation, and recreational facilities. Increased business activity may demand additional office accommodation, warehousing and other construction. Municipal services, such as utilidors, water treatment and supply, sewage and waste disposal systems and public utilities for power, heating and communications will require extension and upgrading. Pressures on accommodation and facilities should increase up to 1981 and beyond.

As an example of the volume of secondary construction activity which may occur, there may be a regional backlog of from 4,000 to 5,000 housing units by 1983 (Gemini North, Vol.2, Ch. VII, pp.589-594). Prefabricated units and mobile homes will doubtless be widely used, at least temporarily. Even so, building construction firms could be fully extended to handle the contract work involved, which at 0.58 man-year per unit, could total 300 to 400 man-years of labour per year over a seven-year period.

Building sub-trades should benefit proportionately with the rise in building construction. Plumbing, heating, electrical and other sub-trades will be able to provide year-round jobs within the community. The problem will be to find sufficient experienced manpower to carry out the contracts.

Population growth will increase the pressures for extensions and improvements in municipal services and public utilities. Construction of most municipal facilities will be carried out by the territorial government; electrical transmission and distribution systems by the utilities companies. Considerable local sub-contract work may be available. However, schedules will tend to be more rigid than in the past.

To sum up, most primary direct construction is subject to stringent logistics requirements but some primary indirect construction and most secondary construction should be more flexible as to scheduling. Generally, contracts related to the pipeline and its facilities will involve work at campsites remote from communities. Much primary indirect construction and most secondary construction will be carried out within communities, where local labour turnover will be less severe, and where seasonal problems will be less serious than on the pipeline right-of-way. Much of the latter can be broken down into small contracts with little loss of efficiency, or local contractors could perhaps tender collectively for larger contracts. Local secondary contracts would appear to present less danger of over-expansion of local firms. Also, the kind of experience gained would tend to be of long-term and continuing value.

A mechanism such as the "Study Region Economic Liaison Group", proposed by the Applicant, could assist local contractors in finding suitable contracts, both primary and secondary, which will be available, with information as to their nature and

size.

In the long term the pipeline and associated activities should have a marked effect on the capability and capacity of the regional construction industry. The continued exploration for, and development of, petroleum reserves in the Study Region and adjacent areas, highway construction and community development, should offer a continuing variety of opportunities. Improvements in capacity and capability could result not only from the growth of firms that already exist in the Study Region, but also from the addition of new entrepreneurs from the South.

Highlights

1. The capacity of the construction industry of the Study Region to participate in a project as large, rigorous and complex as the proposed pipeline is quite limited. However, firms working in cooperation could perhaps play a role in some aspects of the project.

2. Regional building construction firms will have little opportunity to work on direct pipeline projects and installations. However, secondary construction activities should provide contract work to building contractors and sub-trades to the full extent of their capacity. Such work will include construction of housing, schools, hospitals and other facilities. Much of this activity will take place in the main Mackenzie Valley "action" communities such as Hay River, Fort Simpson, Norman Wells and Inuvik.

3. Inuvik should be the scene of greatest activities, not only because of the pipeline, but also owing to the development of gas reservoirs and other petroleum activity.

4. In the long run, capacity of the regional construction industry to handle larger and more complex projects should increase because of the pipeline and associated activities.

5. Establishment of a "Study Region Economic Liaison Group" along the lines proposed by the Applicant should assist local construction firms, as well as other sub-trades and suppliers, to participate in pipeline-induced activities to maximum advantage.

4.12 COMMERCIAL SERVICES

Background

Commercial services in the Study Region can be grouped under three broad activity headings, namely, personal services, services to business, and accommodation and food establishments. Personal services include shoe repair shops, barbers and beauty salons, laundries and cleaners, funeral services, guiding for fishing lodges, automobile rentals, photographic services, and various non-profit organizations and clubs. Total annual employment in such services for the Study Region has been estimated at about 110 to 125 man-years (Gemini North, Book 2, Vol. 4, Ch. V, pp.254-255).

Services to business include employment agencies, security services, accountants, engineers, architects, lawyers, advertising services, business consultants, and related similar activities. Total annual employment in these has been estimated at 69 man-years (Gemini North, Book 2, Vol. 4, Ch. V, pp.256-257).

In the area of accommodation and other tourist services such as restaurants, hotels, motels, beverage rooms, etc., Gemini North Ltd. has estimated the total annual employment from 72 establishments in the Study Region is equivalent to 386 man-years (Gemini North, Book 2, Vol. 4, Ch. V, pp.258-261). Total annual employment, therefore, from commercial services in the Study Region is equivalent to about 570 man-years.

Commercial services accounted for approximately 8 per cent of total economic activity in the Northwest Territories in terms of wages and salaries paid during 1973. The largest individual service activities were restaurants and catering (30 per cent), hotel and lodges (19 per cent), taxicabs (13 per cent), garages (11 per cent), building maintenance (7 per cent), and engineering (6 per cent). During the 14-year period ending in 1973, commercial services activity grew one and a half times as fast as the territorial economy, an indication that there was perhaps a trend towards a greater balance in the economy of the Northwest Territories (Resources Management Consultants Ltd., pers. comm., 1974).

In the absence of pipeline development, it is expected that commercial services in the Northwest Territories will grow at an average annual rate of approximately 7.5 per cent in terms of total wages and salaries paid (constant dollars) in the intermediate future, and that increases in wages and salaries during that period will be spread evenly among the three groups of commercial service activities.

Impact of the Pipeline

Issues

The following are particularly important with respect to the topic:

(i) the effect of pipeline construction and operation on the market for commercial services;

(ii) the effect that the pipeline may have on commercial services through affecting the cost and availability of scarce labour resources.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains reference to issues related to the foregoing, particularly the first issue (Guideline 4), and this has prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant believes that the greatest potential for pipeline-induced secondary employment and income generation is in the service industries which employ 75 per cent of the labour force of the Study Region (Sect. 14.c, p.32). The Applicant's definition of services, however, is much broader than the one used here and includes transportation, communications, construction, utilities, wholesale and retail trade, finance, community services and government.

The Applicant expects that expansion of personal and business services will be greater proportionately than the population increases resulting from pipeline development. He observes that accommodation and food service establishments already face demand pressures which, in his opinion, will clearly be accentuated as a result of pipeline construction and operation" (Sect. 14.c, p.32).

Commentary

The most significant opportunities for direct benefits to commercial services as a result of the pipeline will be in catering. Currently there are eight caterers along the Mackenzie Valley, including one at Pine Point, four at Inuvik, and three at Yellowknife (Gemini North, Book 2, Vol. 4, Ch. V, p.267). None of these would have the capability to meet the total needs of the pipeline construction camps; however, working in cooperation, they could probably meet a significant proportion of these needs.

Restaurants, bars, and accommodation in the Study Region should experience considerable growth as a secondary effect of increased population and income, and especially of the increased number of transient workers, even though these workers will have restricted access to communities. In this regard, the Applicant mentions that he has established a broad policy of minimal disruption to the communities (Sect. 14.c, p.37). However, he has not stated specifically what controls will be taken. For example, the arrangements that will be necessary to handle the large number of workers travelling from the South to construction camps have not yet been made. One source has estimated that the communities of Fort Simpson, Norman Wells, and Inuvik will each be subjected to the passage of at least 125 transients per day during peak periods (MPS, Vol. 1, p.99). Presumably transportation would be coordinated so that accommodation requirements would be kept minimal. Nevertheless, hotel facilities in the Study Region presently are operating at near capacity, and new facilities will likely have to be constructed even if they would be used only in case of an interruption of normal transportation arrangements. This would seem to provide some opportunities for local entrepreneurs.

There probably will not be many opportunities for direct work on the pipeline in the area of personal services. However, the secondary effects of increased population and spending power as a result of the pipeline could be significant. The same could be true of the impact of the pipeline on services to business; the combination of increased population and incomes should result in an increase in the number of businesses and sales volume in general in the Northwest Territories. This in turn should result in an expansion of professional and other services provided by lawyers, accountants and consultants, and for taxis and garages.

On the negative side, the proposed pipeline might well compete with various commercial services for use of northern labour. The food and accommodation industries could have difficulty in meeting

their labour requirements, as might other industries in the commercial services sector. However, since these services offer considerable year-round employment in the larger communities, and since many firms would be in a position to raise prices to compensate for rising wage costs, the effect of such competition may not be serious.

Highlights

1. Pipeline-induced activities will have an indirect but significant effect on commercial services.

2. The already overburdened accommodation and food service establishments are unlikely to expand sufficiently to avoid even greater pressures on their facilities unless early attention is given to the demands the pipeline and associated developments will introduce into this sector.

3. The pipeline may have some minor impact on labour available to commercial service industries.

4.13 FINANCIAL SERVICES

Background

The financial facilities in the Study Region may be grouped conveniently under two broad categories. Firstly, there are private facilities which consist of commercial banks and insurance and investment companies. The location of these facilities is confined to the larger settlements, particularly Inuvik, Hay River, and Yellowknife. Of the eleven commercial banks in the Study Region, seven are located in the Slave Sub-region, an area which the proposed gas pipeline will not traverse. Total employment in commercial banking is about 120 persons (Resources Management Consultants Ltd., pers. comm., 1974).

The commercial banks of the Study Region offer services including as complete a line of mortgages as that in Southern Canada, and personal loans at the same rates of interest as in the South. However, northern banks are small and the majority typically limit the amount of loan to five thousand dollars although there would of course be exceptions to this. In fact, two thousand dollars may be about the average amount of a personal loan that regional commercial banks have been granting to borrowers. Yet, it is reasonable to assume that these banks could provide an increased flow of at least working capital finance if the number of sound business ventures in the Study Region increased. No data are available to permit an assessment of the financial activities of the few insurance and investment companies that operate in the larger towns of the Study Region.

Secondly, in addition to the commercial banks, insurance and investment companies, there are also government-operated financial facilities in the Study Region. These facilities include the Indian Economic Development Fund, the Eskimo Loan Fund, the Fishing Boat Loan Fund, the Trapper's Assistance Fund, the Small Business Loan Fund, and the Industrial Development Bank.

Northern entrepreneurs face a number of financial and managerial problems that tend to act as a restraint on the growth of economic activity in the territories. Among these problems are the relatively high cost of northern business operations, the difficulties of access to equity capital and managerial skills in the North, and the absence of a range of specialized financial services that are normally found in southern Canada. The larger business operations in the Northern Territories function as branches of southern-based companies and therefore are not as seriously handicapped by these financial and managerial problems as are small local business operations.

Impact of the Pipeline

Issues

The following are of particular importance with respect to this topic:

(i) the effect of the pipeline on the regional demand for finances and working capital;

(ii) the adequacy of the supply of such capital.

Applicant's Statement

The Applicant does not give any consideration to the impact that the proposed pipeline might have on the financial facilities of the Study Region.

Commentary

The proposed pipeline is likely to create opportunities for small business development in the Yukon and the Northwest Territories, particularly in services and in small secondary industries. These business opportunities will in turn result in an increased demand by entrepreneurs for loan capital.

Indian and Eskimo businessmen of the Northern Territories have access to public sources of capital at relatively low rates of interest, but it may be that some Native people are not fully aware of the existence of loan funds that are available for their exclusive use. Of more pressing concern, however, is the fact that the number of Natives who possess managerial skills is relatively low. If the essential management skills of the Northern Native people could be raised relatively rapidly, they could take better advantage of the economic opportunities that are likely to be created by the pipeline project.

The White and Métis populations comprise the major entrepreneurial group of the Northern Territories. Yet these people have only limited access to funds or services that could help to alleviate problems of business finance that they encounter, and that could provide them with management advice. In comparison with businessmen in the provinces, their position is one of considerable disadvantage. It would be difficult for northern entrepreneurs to take full advantage of opportunities provided by the pipeline under the circumstances.

Highlights

1. The pipeline project will create business opportunities in the Study Region and this will increase the demand for finance capital.

2. Such capital is available to Native people under a number of programs but they may not be sufficiently aware of this, nor have they the managerial skills that would enable them to take full advantage of it.

3. By national standards, the White and Métis entrepreneurial group of the Study Region is at a substantial disadvantage with respect to being able to obtain finance capital and business advice.

4.14 WHOLESALE AND RETAIL TRADE

Background

Most of the consumer and household goods that are sold to the general public in the Study Region are imported directly from wholesalers in the provinces, mainly Alberta, since there are few wholesalers in the region. Local wholesalers operate from the larger communities such as Yellowknife and Inuvik, and confine their activities to the sale of such items as bulk fuel, building equipment and general merchandise.

Retail outlets are to be found in every community in the Study Region with the exception of Enterprise and Kakisa Lake. While these outlets are relatively well developed in the larger communities, they are rudimentary in the smaller centres. The dominant retail outlet in the Study Region is the Hudson's Bay Company which operates in most communities. Altogether, there were approximately 124 trade establishments providing an estimated total of 460 man-years of employment in the Study Region during 1973 (Gemini North, Book 2, Vol. 4, Ch. V, pp.242-244; "NWT Community Data", 1974).

Competition in the retail trade sector is a minimal factor, though it is claimed that the Hudson's Bay Company is a deterrent to the establishment of small retail outlets which could be operated by Northerners (Gemini North, Book 2, Vol. 4, Ch. V, p.244). Other factors which tend to impede the growth of trade establishments in the North include operations of southern mail-order companies, high inventory costs on staple goods which typically are shipped once a year, high transportation costs and freight charges, lack of managerial skills, and the smallness of local markets.

There is a scarcity of published data on the trade sector of the Study Region, but regional wholesalers and retailers who were contacted suggest that their businesses are profitable ventures. The upward annual trend in the volume of these businesses has been attributed mainly to increases in population and income. There is evidence, however, to suggest that there has been some decrease in the actual rate of growth of retail trade since 1971. In 1970, the value of retail trade in the North was estimated at $56.9 million; the estimated values for the years 1971, 1972, and 1973 were, respectively, $67.4 million, $75.7 million and $82.7 million (Statistics Canada, unpublished worksheets).

Retail mark-ups in the North are generally in line with those in southern Canada, although they do vary within the Study Region, reflecting high freight costs between supply sources and widely scattered settlements.

Impact of the Pipeline

Issues

The following are considered important with respect to the topic:

(i) the effect of the pipeline on the regional market for goods, and hence on the retail and wholesale trade sector;

(ii) any effect the pipeline might have on retail and wholesale trade by reducing the supply of scarce regional resources such as labour.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references to issues related to the foregoing—particularly the first issue (Guideline 4)—from which

has stemmed "Requests for Supplementary Information."

Applicant's Statement

The Applicant's treatment of the impact of the pipeline on the trade sector of the Study Region is general and brief. He states his intention to purchase materials, supplies and services from local suppliers only where such purchases will be consistent with the full range of his responsibilities (Sect. 14.c, p.37). Beyond this, he suggests that the expansion of wholesale and retail trade is expected to be greater proportionately than the population increases resulting from pipeline development (Sect. 14.c, p.32).

Commentary

It is considered that the present capacity of the trade sector of the Study Region would be unable to meet major upsurges in demand, especially in the retail sector. Indeed, most retailers in the North believe that they would need at least two years' advance information on pipeline routings, schedulings and requirements before they could expand their establishments to meet any of the requirements posed by the project.

Pipeline construction workers will live in self-sufficient camps located on the right-of-way, well removed from communities and settlements. Altogether, there will be 27 such camps over the three-year construction period (Sect. 13.a.2.2., Route Maps). No one company now has the capacity to meet the total consumer goods requirements of individual pipeline construction camps. However, if supply contracts were broken down into smaller units, local businesses working in cooperation might be able to meet a significant proportion of these requirements. Retailers of the Study Region should benefit from expenditures made by transient construction workers seeking sundry and luxury items (e.g. handicrafts and fur garments) as well as recreation in the communities.

The construction of the pipeline will give rise to increased employment in a number of pipeline-induced activities. This should result in increased consumer spending in the Study Region, and local retailers and wholesalers should benefit from this. Larger communities such as Hay River, Fort Simpson, and Inuvik are likely to be particularly affected although most Mackenzie Valley communities will benefit to some extent.

The Applicant has cautioned that care must be exercised to avoid unjustified expectations about the volume of goods and the duration of increased business associated with pipeline construction (Sect. 14.c, p.37). The potential problem relates partly to the fact that construction activities will be moving from one area to another, and partly to the fact that the level of these activities will be seasonal.

There will be an impact on the wholesale and retail trade sector during the operating phase of the pipeline. If, on the one hand, most permanent pipeline workers were recruited from outside the Study Region, the population of the region would increase considerably, with increased demand for consumer goods. On the other hand, most permanent pipeline workers could be recruited from the existing work force in the Study Region. A portion of the job vacancies created through such an employment shift would have to be filled by either transients or people from other parts of the Northern Territories. The combined effect would be some net increase in regional income levels resulting in increased consumer spending. The true situation probably will fall somewhere between the extremes.

The Applicant and his contractors undoubtedly will

want to employ many of the better trained and qualified residents of the Study Region. Some of these people will be found in the retail and wholesale trade sector, and merchants may at times have problems holding staff. However, because they can offer steady, year-round employment in reasonably comfortable surroundings, the problem likely will not be a major one.

Highlights

1. The pipeline could cause a significant, direct, short-term increase in regional retail and wholesale trade if regional merchants are able to increase capacity sufficiently to obtain and meet pipeline supply contracts.

2. In the long run, the pipeline could bring gradual benefits in retail and wholesale trade through pipeline-induced growths of regional population and income.

3. The pipeline is likely to have only a minimal impact on the retail and wholesale trade sector through competition for scarce regional labour.

4.15 MANUFACTURING

Background

Most of the manufacturing enterprises of the Northwest Territories are located in the Study Region, and as much as 70 per cent of them are to be found in the Slave Sub-region. These enterprises are of small scale, employing approximately 108 persons in 1973, a figure which at the time represented less than 1 per cent of the total labour force of the Northwest Territories (Resources Management Consultants Ltd., pers. comm., 1974). In the Yukon Territory any manufacturing lies well outside the Study Region, which includes only the small community of Old Crow.

The manufacturing industry accounted for approximately 1.7 per cent of all economic activity in the Northwest Territories in terms of wages paid in each year from 1961 to 1970 inclusive (Statistics Canada, and WCB). Wages in the manufacturing industry grew at an average annual rate of approximately 12.8 per cent, while total wages in the Northwest Territories were growing at an average annual rate of approximately 13.2 per cent during that period (Statistics Canada, and WCB). Thus it would seem that wages from manufacturing and total territorial wages were growing at about the same rate during this period.

The development of the manufacturing industry in the Study Region is severely restricted by, among other things, the high cost of services (including transportation and energy), the high cost of imported labour and the low productivity of local labour, low average incomes, the lack of capital and managerial skills, and the small and widely dispersed territorial market. In spite of these factors, the manufacturing industry should continue to grow in the immediate future, and in the absence of the pipeline development, at a rate equivalent to the growth of Study Region population.

The industry might well grow at a faster rate due to increased substitution of goods that are now imported into the Northwest Territories. Market-seeking industries which could become viable during the immediate future include prefabricated housing, concrete products, dairy products, boat building, paper products, and the manufacture of furniture. These are all mature industries in the sense that they are based on well known, fully developed technology. Moreover these are industries which achieve only moderate economies of scale, a feature which, combined with high transportation costs for competing products could allow the products of relatively small northern plants to be sold at competitive prices.

Impact of the Pipeline

Issues

The following would appear to be of particular importance with respect to manufacturing:

(i) the effect of the pipeline in providing markets for new or existing manufactured products in the Study Region;

(ii) competition by the pipeline for scarce labour resources and the effects of this on regional manufacturing.

Applicant's Statement

The Applicant states that any manufacturing enterprise that is largely dependent on local markets will have improved prospects as a result of pipeline-induced increases in population and the increased over all level of economic activity (Sect.

14.c, p.32).

Commentary

The provision of markets for new and/or existing products will come about through stimulated demand as a result of increases in population and income. To the extent that residents of the Northwest Territories will be employed on the pipeline, these jobs will provide increased incomes and spending power there. One source has estimated that the average income would be 10 to 15 per cent above present levels for White workers, 50 per cent to more than 100 per cent above present levels for Native workers, and that the gross additional cash income would be about $4.8 million during the peak year of pipeline construction (MPS, Vol. 1, p.25). This amount is equivalent to an increase of 4 per cent of the total 1973 wages and salaries in the Northwest Territories, and could result in a similar increase in manufacturing activity in the Study Region (Statistics Canada, 1973; WCB, 1973).

Gemini North Ltd. states that there will be an increased demand for a number of goods that can be produced advantageously in the Study Region (Gemini North, Book 2, Vol. 4, Ch. IV, p.127). Included among these goods are bakery products, beverages, concrete and paper products, boats, printed material, furniture and fur garments. The food industries will benefit from any increases in population and income. With aggressive action and with the cooperation of the Applicant, these food industries perhaps could secure contracts to supply construction camps.

Although the printing establishments at Yellowknife and the canvas and fiberglass operations at Fort McPherson and Fort Providence will benefit from increases in both population and income, it is unlikely that they will have any opportunity to do work directly for the pipeline company. However, there should be good opportunities in the fur garment industry by the demand created by pipeline workers for parkas; the welding and metal fabricating enterprises of the Slave Sub-region should receive a considerable boost from pipeline activity. On the other hand, whereas the single box and wood products enterprise in Yellowknife will benefit from increased construction activity, it probably would have little capability to undertake pipeline work unless it expanded its capacity.

Territorial manufacturing establishments are not likely to be called upon to supply goods and materials directly for pipeline construction because the scale of their capabilities is not large enough, nor their schedules sufficiently reliable Two possible exceptions are the manufacture of prefabricated or modular residences and construction camps. However, a fabrication plant would not be viable if it were to serve the needs of the pipeline exclusively; there also would have to be a longer term prefabricated housing market elsewhere in the Northwest Territories and perhaps also in contiguous regions. The feasibility of establishing a concrete products industry in the Northwest Territories could be enhanced by virtue of the pipeline's requirements for concrete products.

On the negative side, by offering higher wages and creating a demand for labourers of all types, the pipeline could draw workers away from the regional manufacturing industry and create wage increases across all industry. Increases in wages would certainly erode any cost of production advantages that the northern manufacturer might enjoy over his southern counterparts. Save for establishments that employ mostly women, manufacturing firms are particularly vulnerable to the loss of workers because many of those they employ are among the most reliable members of the northern labour force.

Highlights

1. Population increases and income induced by the pipeline should significantly expand the market for regionally manufactured goods.

2. Increased wage rates could result from pipeline activity and erode advantages that regional manufacturing firms might have over outside competition.

3. Regional manufacturing firms could have some problems in retaining their relatively experienced and stable labour force because of high wages and other inducements that the pipeline may offer.

4.16 EDUCATION

Background

This section deals with normal in-school and adult education and not with training programs proposed by the Applicant for construction and operation of the pipeline. The latter is discussed in Chapter 3.

Educational services in the Study Region cater to people of diverse cultural, economic, and linguistic backgrounds. These services must meet the requirements of families who have recently moved North and who want to ensure that their children obtain an education of comparable content to that in the provinces. They also must provide for Indian and Eskimo children, whose proficiency in English is not high, and for Native adults, whose experiential and educational backgrounds are different from those of teachers, educators and school administrators. Climate, geography, and sparse population have posed formidable problems to bringing people to the classroom or the classroom to the people.

Currently northern educational services are operated by the territorial governments. Historically, such formal education as existed in the Study Region was provided by the Anglican and Roman Catholic Missions, which had been active in the region almost since the inception of the fur trade, and which are still involved in the operation of residential hostels attached to some schools. The once widespread hostel school system virtually has been abandoned for grades below high school, and the number of schools in small communities has been increased so that children may now remain at home for their early education. However, small hostels are still operated in some communities so that younger children may continue their education while parents are engaged in seasonal hunting,trapping and fishing.

The average level of educational attainment of White residents of the Study Region is as high as, or higher than, that of the rest of Canada. Most Whites have migrated to the Study Region to take jobs that pay well and require substantial training.

In marked contrast, the level of educational attainment among Native people is well below the Canadian average, and attitudes towards formal education are uncertain and ambivalent. While many Native parents recognize that formal schooling would increase their children's chances of finding satisfactory employment, there is a feeling that education has been a major factor in alienating the children from their parents and cultural background. In all but a few communities, children must leave home, often over long distances, to receive secondary education, a fact that makes the prospect of such education less attractive to both parents and children. As yet, there are only a small number of northern Native people who have benefited from education and who can serve as models for the young. Because the circumstances surrounding their education often are difficult, many Native children simply quit trying and leave the formal school system. The drop-out rate among northern Native students is very high. (Gemini North, Vol. II, Ch.7, p. 706).

The number of students graduating from the territorial school system is still relatively small, although it could grow quite rapidly in the near future. Gemini North indicates that there were only 314 gruaduates from secondary schools in the Study Region during the 1963-72 period. (Gemini North, Table 7.31, p. 703). However, it suggests that the number of graduates could rise to 2,200

students during the following (1973-83) decade (Gemini North, Vol. II, Ch. 7, p. 705).

A considerable number of adults are now undertaking educational and training programs in both territories. For example, during the 1972-73 school year, 2,147 adults in the Northwest Territories were taking a variety of vocational education courses which included full-time technical and university-level courses, correspondence courses, adult evening classes, apprenticeship training, and on-the-job training (NWT Annual Report, 1973, pp. 53-54).

Expenditures on education comprise a substantial part of the budgets of the Northern Territories. For example, the education operating budget for the Northwest Territories for the 1973-74 fiscal year was $30,069,000, approximately 25 per cent of the total territorial operating and maintenance budget (NWT Annual Report, 1973, Financial Statements, p.56). Schools in the Study Region are modern, well constructed, and are not crowded.

Impact of the Pipeline

Issues

The following are of particular importance to this topic:

(i) any effect that the pipeline may have on the educational attainment of residents of the Study Region;

(ii) the extent to which the pipeline may affect the capacity of the educational delivery system.

The "Social Guidelines" of the "Expanded Guidelines for Northern Pipelines" do not refer directly to these issues. However, there are references to job training which have prompted questions in "Requests for Supplementary Information".

Information

The Applicant recognizes that there are serious deficiencies in the educational attainment of residents in the Study Region. While he is encouraged by current school enrollment figures, he observes that these reflect a large registration at the elementary level, and that only relatively few students will proceed to secondary or vocational training.

He believes that high school graduates in many cases will go on to university, and states that the number of people who have completed technical training has increased. He observes that few people who have undertaken training have had problems in finding suitable work within the Study Region. He forecasts that during the 1975-85 period, an average of 450 students annually will graduate from high schools in the Study Region (Sect. 14.c, p. 13-14).

The Applicant further states that he does not intend to become directly involved in correcting the educational inadequacies of the Study Region. However, he believes that improved prospects of income and employment, and advantages that will accrue to those who continue their schooling, will make an education more attractive to young people. He therefore feels that development associated with the pipeline will have a positive long-term effect on educational attainment within the Study Region (Sect. 14.c, p.29).

While this section is not concerned with pipeline-related training programs, it should be noted that the Applicant intends to provide certain educational programs that would have a broader application than simply building and operating a pipeline.

For example, he mentions programs on Arctic survival, on various aspects of Arctic natural life, and in basic life skills. Other programs of a broader kind would include courses which would acquaint supervisors and workers from the South with northern Native society (Sect. 14.c, p. 36).

Commentary

The effect of the pipeline on the future educational attainment of residents of the Study Region is difficult to predict. On the one hand, the relative ease of obtaining employment on the pipeline during construction, particularly in winter, could have a negative effect on high school completion. On the other hand, the Applicant is probably correct in his contention that improved prospects of employment and income will generally "raise the sights" of young people of the region in the long run. Good jobs paying adequate incomes would constitute the best kind of evidence that education and training are worthwhile.

Training programs will soon have to be made available to adult members of the labour force if these people are to have sufficient time to acquire some of the skills that might be useful in terms of pipeline and related employment. However, the territorial governments might be reluctant to commit resources to such purposes until a decision has been made with respect to the building of the pipeline.

Little direct impact is expected on school plants from the work force entering the Study Region to build the pipeline. In most cases, employees will be located in camps on single status and will live well away from established communities. However, the impact of workers in activities associated with the pipeline, such as the development of regional gas reserves, is less certain. Some of these people probably will bring their families North with them, and this could raise problems for existing facilities, particularly in the Mackenzie Delta.

Projections for communities that are expected to become regional and district pipeline-operating centres (Inuvik, Norman Wells, and Fort Simpson) suggest marked increases in school-age population due to the pipeline. Additional students would come not only from the families of pipeline employees, but also from the families of government employees and persons in private business. This could lead to a requirement for additional classroom capacity and teaching staff. Other communities such as Hay River and Tuktoyaktuk also could experience a growth of population as a result of activities related to the pipeline. At some point this could put pressure on existing educational facilities.

Highlights

1. Educational attainment among White people living in the Study Region is probably higher than that of Canadians as a whole. For Native people it is well below the national average.

2. In the short run, the pipeline could have a negative effect on educational attainment in the Study Region in that many young people, who might otherwise complete high school or other training, could be attracted into an employment role.

3. In the long run, through demonstrating the value of education and training, the pipeline could have a positive effect on younger Native people.

4. Construction of the pipeline per se is not likely to impose a burden on the regional education delivery system. However, the large degree of secondary activity associated with the pipeline could result in a significant number of

families moving into the Study Region, especially into the Mackenzie Delta. This could create pressures on educational facilities.

5. Communities that will become district operating centres for the pipeline, and some other communities, could undergo a significant increase in permanent population, and this could require an expansion of educational facilities.

4.17 HEALTH SERVICES

Background

Health, and particularly the health of Native people, remains an important problem in the Study Region despite the widespread introduction of modern medicine and improved housing and sanitation. Few statistics are available specifically for the Region. However, data for the whole of the Northwest Territories, which can be regarded as indicative of trends in the Mackenzie Valley, reveal that, insofar as all ethnic groups are concerned, mortality rates have fallen dramatically during recent years into approximate alignment with national rates. However, for Native groups, these rates are still well above national and territorial levels.

For example, the death rate per 1,000 people for the Northwest Territories fell from 15.0 in 1962 to 8.5 in 1971, at which point it was approximately in line with the national rate of 7.3 per 1,000. In the case of Indians living in the Northwest Territories, the death rate declined from 10 per 1,000 in 1962 to a relatively moderate 8.7 per 1,000 in 1971. However, the 1971 rate for Eskimos still stood at 11.2, even though there had been a sharp decline from the 1962 rate of 23 deaths per 1,000 people. The "Other" population; that is Whites and Métis, exhibited a mortality rate well below national and territorial averages, namely 5.0 deaths per 1,000 people. The rate had been approximately at this level over the previous decade.* High infant mortality rates are a major factor accounting for higher death rates among Native people, whose life expectancy is still generally well below the Canadian average.

Injuries, violence and accidents are well in excess of all other causes of deaths in the Northwest Territories, accounting for some 20 to 30 per cent of the total. These are followed by categories such as pneumonia (10 to 20 per cent) cancer (10 to 15 per cent), diseases of infancy, prematurity and malformation (10 to 18 per cent), and cardiovascular diseases (10 to 15 per cent). Tuberculosis, the great decimator of former times, has been reduced to virtual insignificance. In 1947 at 687.5 deaths per 100,000 people, the death rate from tuberculosis alone was nearly equal to the 1971 rate from all causes. By 1970, this had fallen to a mere 9.1 deaths per 100,000 people. This does not mean to imply that tuberculosis is no longer a factor. Numbers of new active cases are still significant, particularly among Eskimos.**

Patterns of illness and poor health are difficult to ascertain with any precision because opportunities for thorough diagnosis tend to be quite limited. A tabulation prepared by Gemini North for the Mackenzie and Inuvik health zones indicates that, of a total of 23,872 visits to nursing stations and health centres between January 1st and August 31st, 1973, 18 per cent were about skin conditions, 13 per cent concerned ear, nose and throat conditions, 8 per cent were about cuts, bruises and sprains, 7 per cent were about bronchitis and other respiratory diseases, and 7 per cent were concerned with gastro-intestinal conditions. Thus these six general categories accounted for nearly 70 per cent of all visits (Gemini North, 1974, Vol. 2, Table 7.21, p.653).

The foregoing percentages indicate why people may visit health centres and nursing stations, but they are only crudely suggestive of the general health of the population. A relatively high

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*"Report on Health Conditions in the Northwest Territories, 1964-1971", Northern Health Service, Dept. National Health & Welfare, Ottawa, 1965-1972; and Stat. Can. "Vital Statistics", Cat. #84-201.

**As above, for years 1965, 1966, 1968 and 1971.

incidence of colds and flu could indicate that people may not be sufficiently well nourished to withstand various mild virus diseases that normally circulate, or that shelter is sub-standard and crowded. Similarly, a high incidence of gastro-intestinal ailments might suggest that sanitation is poor, food tends to go bad, or that people are having difficulty in adjusting to new foods.

Excessive use of alcohol may also be a factor in poor health. Liquor consumption per capita in the Study Region is substantial, and many residents view it as the most important problem affecting their lives. In physiological terms, alcohol contributes to poor nourishment and the deterioration of the stomach, liver and other organs. The effects of prolonged heavy drinking on the central nervous system have also been well documented. Alcohol is believed to be a major contributive factor in the high number of deaths by violence that occur in the Northwest Territories, being involved in some 40 to 50 per cent of such cases. It is also known to play a major role in various social problems such as child neglect and family break-up.

There may be serious problems of mental health in the Study Region. For example, drinking is accompanied by hostile and aggressive behaviour with sufficient frequency to suggest that these traits are latently present among a significant proportion of the population. Anxiety, depression and hysteria are believed to be quite common. Factors which may have contributed to behavioural disorders would include overly rapid change, cultural displacement, low income, the severe climate and isolation. However, the causality that is at work is not well understood.

Venereal disease, and particularly gonorrhoea, has been rising rapidly. For the Northwest Territories as a whole, the incidence of gonorrhoea has recently exceeded 4,500 cases per 100,000 people; the Canadian rate is about 100 cases per 100,000 people. About 70 per cent of the people afflicted with the disease are in the 20 to 30 age group. The annual growth rate of new cases during the 1968-71 period for the population of the Northwest Territories as a whole was 33.7 per cent. In 1971, the Northern Health Service, Dept. National Health and Welfare indicated that about 66 per cent of all the recorded cases of gonorrhoea occurred in the Fort Smith and Inuvik administrative regions, an area roughly equivalent to the Study Region.

The health delivery system of the Study Region is administered by the Northern Health Service of the Dept. of National Health and Welfare on behalf of the Government of the Northwest Territories. The cost of health and treatment services is shared between the Government of Canada and the Territorial Government under various arrangements. The health care costs of registered Native patients are absorbed by the Government of Canada while the Territorial Government bears costs incurred by non-Natives.

The Northwest Territories became a participant in the national program of public medical care in April, 1971. The territorial health insurance plan covers all services rendered by qualified medical practitioners but excludes such services as chiropractic, optometry and most dental work.

Health services delivery in the study area is characterized by the fact that outside of the larger centres of Inuvik, Norman Wells, Fort Simpson and Hay River, public health nurses and nursing stations are the main health-care resources. The smallest type of health facility is known as a Health Station and is typically installed in a community ranging in population from 50 to 200 persons. It is usually staffed by a local lay person who has received some first aid training. Smaller communities with populations of more than 200 may qualify for a Nursing Station with a regular nurse. A population in excess of

300 persons may warrant a second nurse, and another nurse may be added when population exceeds 700. Attempts are made to place a doctor in a community when it has reached more than 1,000 persons.

Hospitals and resident doctors are located at Inuvik, Fort Simpson, Hay River and Yellowknife. There are some 21 doctors available to these hospitals—12 being in Yellowknife (Gemini North, 1974, Book 2). Aklavik, Fort McPherson, Fort Good Hope, Norman Wells, Fort Norman, Fort Franklin, Wrigley, Fort Liard and Fort Providence have Nursing Stations, generally with one nurse resident in the community. The settlements of Colville Lake and Nahanni Butte have Health Stations, while Jean Marie River and Trout Lake have no local health care and are serviced from Fort Simpson.

Impact of the Pipeline

Issues

The following are particularly important with regard to this topic:

(i) the effects of the pipeline on the health of the residents of the Study Region;

(ii) the effect of the pipeline on the capacity of the regional health delivery system.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references which relate to the issues, and particularly the second issue (Guideline 8).

Applicant's Statement

The Applicant states that progress in health care, housing and health education have raised the health of Study Region residents. However, he recognizes that improvements are still needed, citing high infant mortality rates and short life expectancies at birth as evidence of low relative standards. He further recognizes that poor and over-crowded housing, and inadequate recreational and social facilities contribute to physical and mental health problems. He feels that the most serious consequence of dietary changes among Native people has been a deterioration of dental health. Alcohol is given special recognition both as a problem in itself and as a factor contributing to further problems such as violent and accidental death, crime and child neglect (Sect. 14.c.3.7, pp. 16 and 17).

As to the future, the Applicant believes that the increased employment and income that should result from the pipeline and related developments should continue the trend toward better health. Higher income and employment should make possible improvements in housing, education and urban services.

The Applicant is uncertain about the effects of a higher level of disposable income on alcoholic abuse. However, he is of the opinion that improvements in the standard of living could lessen some of the tensions and anxieties that now contribute to heavy drinking. Generally he feels that the impact of the pipeline will be positive, although the point is not made forcefully (Sect. 14.c.4.7, pp. 30 and 31).

Various proposals that are not directly related to health could have some bearing on health problems. For example, the Applicant observes that recreation facilities are badly needed in the Study Region, and expresses the intent to share any facilities constructed for his staff with local communities (Sect. 14.c.5.6, p.38)

The Applicant states that construction camps would be self-sufficient regarding emergency health services (Sect. 14.c.5.7). No statement is made however, with respect to meeting the additional

health needs imposed on settlements by employees of sub-contractors (e.g., building wharves, operating borrow pits, etc.).

The Applicant admits hospital centres in the region would be used during the maintenance phases for seriously ill or injured employees (Sect. 13.b.2.2), and that he would be prepared to assess the capability of existing facilities to ensure that his operating and maintenance employees will have proper medical and dental care (Sect. 13.b.2.2.2). However, no such comment is made with respect to the construction phase.

Commentary

It is probable that the Applicant will adequately look after the most direct health-care needs of his employees, and will minimize some potential health problems through preventing undue contact between these employees and local people during construction. The direct impact of the pipeline on health may, on balance, be relatively moderate.

There may be a number of undesirable impacts of a less direct nature, however. For example, higher incomes will not do very much to ease physical hardship and mental stress in the Study Region if there are shortages of basic necessities such as accommodation, or if the cost of living rises at a sufficiently rapid rate to negate cash income gains. As another example, pipeline activity is likely to attract speculative transients to the region, and this could affect the well-being of the residents of communities such as Inuvik and Fort Simpson. Pipeline construction could engender significant stress on the family by requiring husbands to be away from home for substantial periods.

Possible adverse effects could occur if workers from the South became exposed to diseases such as infectious hepatitis and carried the disease home with them while on crew rotation. This could perhaps occur before large semi-permanent camps were set up, when employees engaged in transportation and stockpiling may have to use overcrowded local eating and sleeping establishments. Similarly, southern workers could introduce new strains of influenza, staphylococcus, etc., to small and relatively isolated northern populations.

The effect of pipeline development on the health delivery system should be considered in relation to the size of the community, and with respect to the phase of pipeline development. The large communities of Inuvik, Hay River and Yellowknife have a reasonably adequate complement of medical staff (with the possible exception of staff such as physiotherapists, nutritionists, etc., and medical specialists) and fairly large public hospitals that should be able to care for an increased patient load for short periods pending the evacuation of patients to the South. However, the other public hospital in the Study Region (at Fort Simpson) has only 12 beds and only one doctor, and there is little potential for intermediate care at that centre. The small, company hospital at Norman Wells also has little potential for accepting patients above present levels.

While the Applicant does not acknowledge that pressures would be placed on the health-care delivery system during pipeline construction and the operation, it is reasonable to expect such pressures despite the fact that his work force should be a healthy population. In particular, unless medical staff and one or more temporary hospitals are located between Inuvik and Norman Wells, difficulties may be experienced in meeting additional needs for medical services that could arise within community populations as well as the pipeline work force during construction.

Provided that there is joint planning between the Applicant and the responsible levels of government with regard to the adequacy of health staff and

facilities needed during the operation phase, the health delivery system of the Study Region should be improved and the total population should benefit. An important problem that must be resolved is attracting (and keeping for a reasonable period of time) the necessary range of professional staff.

Highlights

1. During pipeline construction, the labour force employed directly on the pipeline will be isolated from Study Region communities and its health care needs should be adequately looked after provided that the Applicant installs sufficient temporary medical facilities along the right-of-way.

2. Physical and mental health problems may arise more indirectly, however, as a consequence of factors such as increased speculative transient population in the main territorial communities, family relocation, or absence of husbands from families for extended periods, etc.

3. Pipeline workers from the South could carry diseases such as infectious hepatitis back to their home communities during crew rotation, etc. Similarly, northern population could become exposed to diseases from which they are currently shielded by their isolation.

4. Regional activity and population inflows, particularly during the construction phase could impose a burden on the regional health delivery system that may well be beyond the capacity of the system. Some expansion of staff and services may therefore be required.

5. During the operations phase, the need to provide health services to a larger resident population than the current one should lead to improvements in the health delivery system of the Study Region.

4.18 SOCIAL ASSISTANCE

Background

Basically the same variety of social assistance programs is available to residents of the Study Region as is available in the provinces. In addition there are a number of territorially operated programs such as economic assistance to the unemployed, child welfare services and assistance to single-parent families. The last-named programs, which are subject to joint federal-territorial funding under the Canada Assistance Plan, are the focus of present discussion because they are the only category of social assistance upon which the pipeline is expected to have a significant effect.

During recent years payments under such social assistance programs rose rapidly in the Study Region. Data developed by Gemini North indicate that all such payments increased from $495,294 in fiscal 1968-69 to $1,002,504 in 1972-73, an average annual increase of close to 20 per cent. On a Sub-regional basis, social assistance payments grew particularly rapidly in the Upper Mackenzie, where the average annual rate of increase was about 30 per cent, and in the Slave Sub-region, where it was about 25 per cent, whereas in the Lower Mackenzie/Delta Sub-region, such payments grew at a mere 3 per cent (Gemini North, Table 7.12, pp. 611-612).

The Gemini data show that, during the 1968-73 period, the economic assistance component of social assistance payments, which typically accounts for about half of all such payments, grew at a higher rate than total assistance in all Sub-regions but the Slave Sub-region, where it grew only a little more slowly. This may be of consequence because the period in question was one of accelerating activity in the Study Region, witnessing activities such as increased oil and gas exploration, highway construction and housing and community development.

Some communities appear to have been the locale of a particularly rapid growth of economic assistance expenditures between 1968 and 1973. For example, the Gemini North data indicate that, in Tuktoyaktuk, such expenditures more than doubled; at Fort Good Hope, they nearly tripled; at Fort Simpson, they almost quadrupled. While the local economy of Fort Good Hope was relatively inactive during the period, Tuktoyaktuk and Fort Simpson were particularly active with respect to oil exploration and highway construction.

Care must be taken in interpreting statistics such as the foregoing. Some fairly major changes took place in the administration and recording of social assistance in the Northwest Territories during the late 1960's and early 1970's, and this makes it difficult to compare realistically data on financial outlays and caseloads. As well, statistics suggesting rising costs could indicate that the quality and geographic scope of social assistance delivery has increased during recent years. Changing lifestyles could require increased social assistance payments. For example, the substitution of more expensive store-bought meats for wild game, and of fuel oil for locally available firewood would lead to a greater requirement for cash in a northern community. Nevertheless, even considering the foregoing, regional social assistance costs arising from economic factors have been increasing at a rate that would suggest that there has been a growth of socio-economic problems in some communities.

Gemini North notes a number of other trends in social assistance in the Study Region such as moderate increases in average community social

welfare caseloads and in the average monthly numbers of individuals on welfare. However, the incidence of individuals on welfare is said to have dropped from 18 per hundred in 1968-69 to 12 per hundred in 1972-73 (Gemini North, Vol. 2, p.610).

No topic that is normally the responsibility of the government is more subject to moral judgment or conjecture than economically based social assistance. In the North, there is considerable speculation on whether "welfare" is destroying work initiative, leading to alcohol abuse and creating a welfare-dependent society. Native people are usually the subjects of such questions.

The answers are not known, but a few observations may be made. First, it would seem that most Native people usually make little money, and take employment whenever there is a real financial advantage in doing so. Secondly, regular jobs that pay well and for which Native people can qualify within a reasonable distance of their communities are still quite scarce. Another factor is that the traditional activities that many people in the Study Region still pursue are risky and often yield low returns in terms of effort expended. The need for supplementary income can therefore be viewed as being quite directly based on economic and social realities even though, as anywhere, some regional residents may occasionally try to take advantage of the system. Finally, because the factors that underlie it are complex, proper treatment of alcohol abuse requires a much more positive and comprehensive approach than the simple denial of social assistance to problem drinkers.

With respect to other types of social assistance, child welfare statistics indicate a gradual increase in the number of children receiving care in various categories during recent years. Accounting in part for this is the fact that child welfare is a new and expanding program in the Study Region. However, in the larger centres, such as Hay River and Inuvik, child neglect and illegitimacy are increasing. There are also reports of an increase in Native children and juveniles being brought before the courts for liquor ordinance violations and various other offences (personal (verbal) communication: RCMP and probation officer, Fort Simpson).

Social assistance in the Study Region is administered either by social workers operating out of a large centre such as Inuvik, Norman Wells, Fort Simpson or Hay River, or by resident case aides, often Native people. Child welfare staff services are almost entirely the responsibility of professional social workers operating out of the larger centres. Shortages of staff and high turnover rates tend to affect the quality of child welfare services in the Study Region.

Services supplementary to the social assistance program, such as nutrition and homemaker advice by home economists, "buymanship" courses, psychiatric consultation etc. are not generally available throughout the North. Support services of a similar type are also not a normal component of the child welfare program. Services that are present in a rudimentary form, and which should be expanded, include nursery school programs, local alcohol treatment programs, and recreation programs aimed at keeping children and teenagers occupied in wholesome activities.

Impact of the Pipeline

Issues

The following are particularly important with respect to social assistance:

(i) the effect of pipeline construction on social problems which may lead to increased economic assistance and other types of social assistance;

(ii) the ability of the social assistance delivery system of the Study Region to cope with social problems that may arise out of the pipeline project.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains references to these problems, and they have provided a basis for "Requests for Supplementary Information".

Applicant's Statement

The Applicant says little about social problems or social assistance services. He states that he will cooperate with appropriate levels of government with respect to public facilities and services, including health and recreation in certain communities where pipeline personnel will be located (Sects. 13.b.2.2.2 and 14.c.4.6.1). His intention to ensure separation of construction-camp facilities from communities is partly based on the possibility that the influx of thousands of transient workers into the Study Region could create serious problems (Sect. 14.c.5.4).

Commentary

There is some indication from data reviewed in the foregoing paragraphs that, as the level of activity and number of jobs in some Study Region communities has risen, there has been a corresponding increase in economically related social assistance. Other forms of assistance, such as those related to health and single-parent families, also appear to have increased. While data are not available on problems such as family break-up and child neglect, they may be more prevalent where a community is undergoing rapid economic and social change.

Some communities in the Study Region have been in a state of social and economic disequilibrium for some time. Many residents of such communities have come to feel unsettled, disoriented and anxious as almost the normal state of affairs. Under such circumstances, a high incidence of social problems is not unusual. Yet, why economic indigence and increased economic activity should apparently go hand in hand is puzzling. If there is some correlation between these two variables, then economic indigence might be expected to increase as pipeline-related employment opportunities become available in the Study Region, although it would seem more plausible that the pipeline would reduce economic welfare dependence. However, under circumstances of major instability, abnormal patterns of behaviour can become prevalent and even dominant.

Even though construction workers will be housed in isolated camps, and care will be exercised in integrating migrant operational personnel and their families into Study Region communities, the sheer magnitude of the pipeline project—the fact that it will impinge on so many aspects of life in a short time—is bound to have a disturbing effect. Insofar as social assistance costs arise out of such disturbances, they could make present high levels of welfare assistance look relatively moderate, during the construction and immediate post-construction periods.

From data reviewed earlier, serious questions could be raised about the preparedness of government social assistance programs to deal effectively with the volume and range of problems that may arise. The extent to which individual and social disorientation could materialize could depend on

how quickly and effectively social problems can be treated as they emerge, and on the thoroughness and wide availability of preventive programs such as counselling, alcohol education, etc. Services that appear to require augmentation or introduction to the Study Region are preventive- and treatment-oriented mental health programs, nutritional and consumer counselling programs, programs aimed at preventing the abuse of alcohol and other drugs, and services designed to assist families under stress. It must be kept in mind that existing and new services will not only be required by permanent residents of the Study Region, but also by some of the transients who enter the region during pipeline construction.

Highlights

1. For reasons that are unclear, some communities of the Study Region have exhibited a pattern suggesting that economically related social assistance may rise as developmental activity affecting a particular community increases. Even so, it would seem that pipeline construction should reduce dependence on economic assistance by the provision of employment opportunities.

2. Apart from economically related social assistance, the sheer magnitude and intensity of the activity arising out of the pipeline project could prove disturbing to communities and individuals in the Study Region, and this could lead to expanded demands on social assistance and services more generally.

3. The scope and state of preparedness of government and community social services catering to individuals, families and children would likely have a significant effect on the degree to which social disturbances arising out of the pipeline can be minimized. Present services in the Study Region appear inadequate to deal with problems as large as those that may arise out of the pipeline project.

4.19 LAW ENFORCEMENT

Background

Throughout the Study Region, most violent crime is unsophisticated, unpremeditated and is associated with alcohol abuse. There is also some indication that rising rates of both alcohol abuse and violent crime are associated with the social and economic dislocations caused by major development. Drug addiction and trafficking is not yet a problem, nor is organized crime. Between 1967 and 1972 the over-all incidence of crime in the Study Region almost doubled, from 16 to 30 per hundred of population (Gemini North, 1974, Vol. 2, Ch. VII, p.749). Crimes against property rose to almost three times the Canadian average, but crimes of violence and assaults rose to at least ten times the Canadian average (Gemini North, 1974, Vol. 2, Ch. VII, Table 7.39, p.74). People of Native origin comprise about 50 to 60 per cent of the population of the Study Region, but 85 per cent of the inmates of correctional institutions in 1971 were Native people (Gemini North, 1974, Vol. 2, Ch. VII, p.799).

A recent analysis indicates that Liquor Ordinance violations account for about half of all crime in the Territories and for 90 per cent of all territorial ordinance violations (Gemini North, 1974, Vol. 2, Ch. VII, p.745), and that alcohol-related offences account for 95 per cent of commitments to correctional centres. Although this would be difficult to prove statistically, one source suggests that alcohol abuse is responsible for 40 to 50 per cent of accidental and violent deaths in the Northwest Territories and for 98 per cent of the child neglect cases, and that it accounts for about 75 per cent of the case-load of law enforcement officers (Gemini North, 1974, Vol. 2, Ch. VII, p.540-1).

Juvenile delinquency, including Liquor Ordinance violations by minors, is also rising. Most offenders are between 13 and 15 years of age. The rate for Indians and Métis children is higher than for Eskimos, and the area including Inuvik, Banks Island and Norman Wells tends to be over-represented at correctional institutions in terms of its share of total regional population. Theft is the most common offence, followed by liquor and motor vehicle ordinance violations. Lack of cash, use of alcohol and seeming parental indifference are said to be behind much of the juvenile delinquency, little of which could be described as of a hard-core character. Many children in the care of correctional agencies in the North may in actual fact be neglected children who might perhaps be more adequately cared for by Child Welfare and family care services than by the correctional institutions (Jubinville Rept., 1971, Sect. b, pp.23-4).

The various law enforcement agencies in the Northern Territories operate within a complex legal and administrative framework, split between federal and territorial jurisdictions. Federal laws include the Criminal Code, the Prisons and Reformatories Act, the Juvenile Delinquents' Act, etc. Territorial Ordinances cover Probation Officers, Magistrates and Magistrates' Courts, and the Establishment and Management of Public and Reformatory Prisons. The Government of Canada appoints a High Court judge, but the Territorial Government appoints the Magistrate and the Justices of the Peace. While the main courthouse is at Yellowknife, the Circuit Court also travels to other centres accompanied by probation officers and other staff.

Policing is in the hands of the RCMP which has between 75 and 80 officers in the Study Region. Numbers of policemen per community vary from one officer in settlements such as Snowdrift to 16 officers plus administrative staff in Yellowknife (RCMP-Yellowknife). Some small communities do not have resident police officers and rely on detach-

ments located at larger regional centres when police services are required. Parole supervision is carried out by territorial Probation Officers who provide this service in addition to their regular duties.

The Territorial Government operates a medium security Corrections Centre and an auxiliary Corrections Camp at Yellowknife. The Centre has a staff of 53 permanent and 10 casual employees and can accommodate 70 men and 8 women. There is now a Community Corrections Centre at Hay River with a staff of 8 and accommodation for 20 inmates. Normally, offenders serving sentences of 2 years or more are sent to a penitentiary in the South. However, since mid-1973 they may, by agreement with the Government of Canada serve their sentences in territorial institutions (Information from NWT Corrections Services).

Impact of the Pipeline

Issues

The following would appear to be particularly important with respect to the subject of law enforcement:

(i) the effect of the pipeline on the incidence and character of alcohol abuse and crime in the Study Region;

(ii) the ability of the regional correctional services to deal with adverse effects that the pipeline project may have on the crime rate and the number of offenders.

The "Social Guidelines" section of the "Expanded Guidelines for Northern Pipelines" contains relevant references to the foregoing, which have prompted "Requests for Supplementary Information".

Applicant's Statement

The Applicant does not specifically deal with the problem of crime and law enforcement. In his description of the Study Region "without the pipeline" (Sect. 14.c.3, pp.14-17) he discusses the social and economic conditions which lead to certain social ills, including alcohol abuse, delinquency and crime. Lack of adequate housing, recreational facilities and meeting places are noted as contributing causes.

He suggests that increased disposable income generated by the pipeline may aggravate the problem of alcohol abuse unless improved housing, health care, recreational facilities, etc., are provided to ease social pressures (Sect. 14.c.3, pp.30-1). He believes his construction program of housing for pipeline personnel, and of recreational facilities for all community residents, will bring about some improvement in the quality of life in northern communities, thereby reducing the incidence of social problems (Sect. 13.c.3, p.38).

He admits that the influx of several thousand construction workers could create pressures on communities. He therefore undertakes to make his construction camps self-contained and to minimize camp-community contacts by formulating adequate control measure in cooperation with community representatives. Drinking in construction camps will be controlled. Also, no firearms will be allowed in camps, a measure primarily designed to protect wildlife, but also serving to reduce possible violence (Sect. 13.c.3, p.37).

Commentary

The highest over-all per capita crime rates in the Study Region in 1969 were recorded in Fort McPherson, Inuvik, Aklavik, Fort Good Hope and

Fort Simpson, all of which were somewhat more affected by activities such as oil and gas exploration and highway contruction than many other Mackenzie Valley communities. Lowest over-all per capita crime rates were recorded in Rae-Edzo and Fort Norman, with Fort Liard only slightly higher (Gemini North, 1974, Vol. 2, Ch. VII, pp.797-8, Table 7.45).

The trend throughout the region has been towards a rising incidence of crime during recent years. The greatest increase has occurred in Fort Simpson since 1969, reaching an incidence of 62 per hundred population in 1972. Liquor Ordinance violations and alcohol abuse have risen dramatically in Inuvik, Fort McPherson and Fort Simpson since 1969 (Gemini North, 1974, Vol. 2, Ch. VII, pp.750 and 755, and Table 7.43, p.566). Observed trends suggest that there is a relationship between the pace of development (both regionally and locally) and the incidence of crime and alcohol abuse. However, data are inadequate to permit any firm conclusion on this matter.

Moreover, records are not reliable in every respect. They record only most serious crimes, and only those known to police and proved to be "founded". They may reflect the orientation of particular law enforcement authorities, or the presence of such authorities in one community and not in another. There is a higher ratio of police to population and therefore greater surveillance in some Study Region communities than in the South.

Unless steps are taken to relieve social problems and pressures, an increase in disposable income could aggravate alcohol abuse and other social problems that are related to crime and violence. With the arrival of southern personnel, unfamiliar with the North or with northern cultures, social pressures will almost inevitably increase. Transient or impermanent personnel tend to bring with them a pattern of heavy drinking which could be reinforced by high cash incomes.

The influx of southern workers or transient jobseekers may bring northern residents into contact with more sophisticated criminal elements, and expecially with drug abuse. Increased cash income and the completion of highway projects will undoubtedly result in a large increase in the number of motor vehicles in the Study Region. Unfamiliarity with motor vehicle use combined with a high level of alcohol abuse could lead to a rapid increase in traffic violations and in accident statistics. The general availability of firearms in the North could aggravate the effects of alcohol or drug induced violence.

Because responsibility for the various correctional services in the Study Region is divided between federal and territorial authorities, difficulties in planning, administration, data collection and follow-through with respect to offenders can occur. In some cases, officials of one jurisdiction are over-loaded owing to lack of personnel in the other jurisdiction. There is at times a lack of cooperation between various services which should be involved in the treatment of the offender, such as health, welfare, family services, probation and parole and corrections. There is some reason to believe that, both in terms of administration and physical plant, the corrections services of the Study Region are not fully capable of dealing with the kinds of problems that the pipeline project is likely to raise.

A recent study of correctional institutions in the North (Jubinville Rept., 1971) recommends, among other things, that an additional Corrections Camp, similar to the one operated by the Yellowknife Corrections Centre, be set up in the vicinity of the pipeline right-of-way, perhaps at Fort Simpson or Fort Good Hope, to handle expected increase in criminal offences. It recommends that the Fort Smith Juvenile Training Centre be supplemented by a

similar, open-style, community-oriented facility and program at Inuvik, and that both facilities, and all matters concerning juvenile offenders should be turned over to the Child Welfare Services Division of the Government of the Northwest Territories.

The report recommends staff development and training programs, the establishment of academic and vocational programs to be operated by the Department of Education within the correctional institutions, and better medical care and recreational programs for inmates. Finally, it suggests the establishment of a Criminal Justice Advisory Council, to involve citizens in research, planning and all aspects of correctional institutions and their affairs. Implementation of at least some of these recommendations could appear to be required if the correctional services of the Study Region are to cope with any increase in crime rates that may result from the pipeline project.

Highlights

1. The incidence of alcohol abuse, crime and violence has been rising in the Study Region. Within the over-all regional population, Native people tend to be involved in prosecutions under Territorial Ordinance and the Criminal Code to a disproportionately high extent.

2. There seems to be a relationship between the pace of development and the local level of criminal offences, but there are few consistent patterns that would permit the conclusion that a higher level of local activity typically results in increased unlawful behaviour. The effect of pipeline construction and operation on the level of incidence of crime in any community cannot be predicted from present information.

3. Crimes currently committed in the Study Region tend to be unpremeditated and unsophisticated. Typically, alcohol is a factor. An influx of population due to the pipeline could introduce more complex criminal activities into the region (e.g. organized drug trafficking).

4. Both the administration and capacity of the current regional corrections system are inadequate in terms of the requirements that the pipeline and associated activities are likely to pose. One major problem is the division of correctional responsibilities between the federal and territorial governments, which results in fragmented effort and inadequate coordination among the various agencies.

CHAPTER 5

LOCAL IMPACT ANALYSIS

5.1 INTRODUCTION

This chapter provides a brief description of the present situation in each community along the pipeline route and an analysis of how the pipeline may affect the community. In the descriptive passages, some emphasis is placed on the economic base, the labour force, and community and government utilities and services. The analysis deals mainly with anticipated physical disturbances that would result from having wharves, stockpiles, construction camps, borrow pits, access roads, etc., locating in or near communities. In addition, attention is given to the likely interactions between pipeline workers and settlement populations, as well as to economic effects such as the employment of local labour, purchase of local goods and services and effects on local hunting, trapping and fishing.

The communities are arranged in alphabetical order. All communities of the Lower, Central and Upper Mackenzie Sub-regions are discussed, but only Hay River and Fort Providence are considered in the Slave Sub-region. In addition, the Yukon community of Old Crow is included.

A considerable volume of material has recently been written on topics relevant to the communities dealt with in this chapter. The reader desiring more information on various subjects touched on here should refer to the Literature Sources (p.14-15).

5.2 AKLAVIK

Aklavik is a hamlet located in the northwestern part of the Delta on the Peel Channel of the Mackenzie River. In 1971 the population was about 575 (Lu and Mathurin, 1973b) and had increased to about 761 persons by 1974 (Community Data, NWT, 1974). The population is a mixture of Indian, Eskimo, Métis and non-Natives, but consists mainly of Native people. Many of the non-Natives have lived in the Mackenzie Delta for a long time. The community is accessible from Inuvik 30 miles away by regular air service, by boat in summer, and by snow and ice road in winter.

The local labour force numbered about 142 in 1969-70, consisting of 74 Native men, 38 Native women, 23 non-Native men and 7 non-Native women. It is estimated that by 1974 the labour force had dropped slightly to 125 (MPS, Vol. VI, Table 19 and Community Data, NWT, 1974). Average annual earned income for individual Native workers in 1969-70 was about $2,000 (MPS, Vol. VI). Per capita income in 1973 was estimated at $940 (Gemini North, 1974, Vol. 6, Ch.II). Native family income for families whose principal income source was wage employment, would likely be in the $4,000 to $6,000 range. However, income would be much lower for families dependent mainly on hunting and trapping or other non-wage earnings.

The main sources of wage income are seasonal employment in the petroleum and construction sectors

(which by and large take place away from the community), and full-time employment in government and community services. There are few full-time hunters/trappers, but a substantial proportion of the Native population participates in the spring muskrat harvest. Hunting caribou, moose and whale, as well as fishing, provide most of the meat required by the hamlet.

The main local retail and commercial enterprises include: general stores and fur traders; a regular air service; a barge service; a winter road to Inuvik; CN telecommunications and television reception; trucking and excavating contractors; fur garment manufacture; public accommodation and fly-in banking services from Inuvik. Government services consist of: a nursing station; schools; welfare services; RCMP; a library; electricity; a post office; docks; an airstrip; and various forms of public housing. Community services include: trucked water and garbage disposal; churches; a curling rink; and a fire department. There are elected hamlet and Band Councils.

Aklavik was formerly a trading, transportation and service centre; it can be typified as a moderately developed, but relatively static community that now is off the main transportation routes. It was expected to decline following the building of Inuvik, but the population has continued to grow slowly. The hamlet could face a shortage of land for residential or commercial expansion.

Extensive use is made of the Delta for trapping, fishing and hunting. Caribou are taken along the eastern flank of the Richardson Mountains from Beaver House Creek to the Rat River (Aklavik, NWT Map, Land-Use Information Series, 1972; and MPS, Vol. 5).

Impact Assessment

The following discussion assumes that the Prime (Coastal) Route and not the Interior Route alternative is used to connect the Alaskan North Slope with the Prime Route in the Mackenzie Valley.

The Applicant does not propose to use the facilities or infrastructure of Aklavik for pipeline construction or operation purposes as the pipeline route is approximately 10 miles due west and there will be no connecting road. However, the Applicant does intend to: install a wharf on the Peel Channel about 20 miles downstream of Aklavik; build 2.3 miles of permanent road from the wharf to the right-of-way as well as non-permanent access roads to borrow sites; build a communications tower, compressor station, airstrip and helipad; and operate a construction camp and a number of borrow pits to produce about 723,000 cu yd of materials. Right-of-way preparations such as construction of the wharf, roads, stockpiles, etc. as well as construction of the pipeline and post-construction cleanup, would extend over a three-year period. No schedule for construction of the nearby compressor station has yet been indicated.

The pipeline could have a significant impact with respect to short-term construction employment of an unskilled nature. Small contractors could participate in the development of the wharf, roads and various pad installations, as well as communications tower and compressor station construction. Residents would not necessarily be employed in the vicinity of the hamlet. Most employment opportunities would be for men. However, camp operation near Aklavik would be required the year round for about three years, and this might provide some employment for local women. Three residents are presently involved in the petroleum-industry training program and the number likely would increase as the program is expanded.

There should be little interaction between the community and the workers brought in from the

South by the main pipeline construction contractors. Control of smaller sub-contractors, who may build the wharf, roads, pads, etc., may be more difficult. If contractors from the community become involved in such activities, there could be considerable interaction with the pipeline. Use of the hamlet's airstrip or wharf is unlikely, except on a temporary or emergency basis while traffic may be awaiting clearance to use pipeline facilities.

It is improbable that the pipeline will have much effect on commercial services. Increased demand for fur garments and handicrafts would likely boost that industry, but the retailing of these commodities would likely occur in Inuvik. Government services in Aklavik should not be particularly affected by pipeline construction activity.

There would be few long-term employment effects on Aklavik as a result of the pipeline. Construction of the nearby compressor station would result in a further year of employment in addition to jobs provided by pipeline construction, but operating personnel for the station would live at the Inuvik Divisional Headquarters for the Delta region.

The proposed right-of-way along the east flank of the Richardson Mountains parallels the caribou migration route, and would be crossed by residents of Aklavik and perhaps other Delta communities during the spring, fall and winter hunts.

Highlights

The pipeline project will have considerable impact on Aklavik, even though the right-of-way will lie a considerable distance west of the community, and there will be only limited access between it and the community. . Local labour will be employed in pipeline construction; the community may be used for some staging and transient passage purposes; and there may be some interference with local hunting, trapping and fishing along the eastern flank of the Richardson Mountains and the western edge of the Delta. However, it is not expected that these various effects will raise problems that are too difficult for the community to handle.

5.3 ARCTIC RED RIVER

Arctic Red River is an unorganized settlement located at the confluence of the Arctic Red and Mackenzie rivers about 20 miles upstream of the Delta. It is on the south side of the Arctic Red River and on the west side of Mackenzie River. Its population in 1971 was 110 (Lu and Mathurin, 1973) and had risen to 122 by 1973 (Community Data, NWT, 1974). It is primarily an Indian community.

The labour force was reported as 28 in 1969-70 consisting of 25 men and 3 women (MPS, Vol. 6). A present estimate would place the total labour force at perhaps 35 people. Until recently, the community experienced an out-migration of young people to Inuvik and Fort McPherson. However, Dempster Highway construction in the area has provided something of a local employment base and young people are now more inclined to remain in the community.

Until recently, the main sources of employment were seasonal hunting, trapping and fishing, and seasonal work in transportation. There was also intermittent employment at the small local sawmill. Although average social assistance for economic reasons has been stable in recent years (1969-73), seasonal unemployment can be high. However, employment opportunities have improved owing to construction work on the Dempster Highway as well as seismic activity on the Anderson Plain. Average annual individual earned income in 1969-70 was in the order of $2,000 (MPS, Vol. 6). A reasonable estimate of Native family income in 1974, derived mainly from wage employment, would

be $3,800 to $5,000.

Settlement and government services are minimal and include: trucked water and garbage disposal; a school; travelling medical and welfare services from Inuvik; a post office; electricity; a dock and barge service; an airstrip (across the Arctic Red River from the community); and a volunteer fire department. Commercial and retail establishments are similarly minimal and include a Hudson's Bay Company store and a fuel delivery service. There are elected settlement and Band Councils. There is adequate land for community expansion, but modern infrastructure is completely lacking.

Native residents hunt, trap and fish in the Upper Delta, upstream along the Arctic Red River and Mackenzie River valleys, and eastward across the Mackenzie River towards the Travaillant Lake area.

Impact Assessment

The pipeline right-of-way and Mackenzie River crossing is about 10 miles downstream from the settlement. There will be a number of activity sites or facilities at or near the Mackenzie crossing. These will include a wharf, a construction camp, a materials stockpile, two borrow pits, approximately three miles of permanent road, a compressor station, a helipad, a communications tower, and the beginning of 30 miles of temporary road. Between the Mackenzie crossing and the Richards Island junction, a distance of about 30 miles, there will be three more borrow pits, a block valve, two helipads, and a communications tower. At this junction there will be: a camp, a 6,000-ft airstrip, a compressor station, a communications tower, and a borrow pit. It is estimated that 367,000 cu yd of borrow materials will be required in the vicinity of the Mackenzie River crossing, and an additional 1,437,000 cu yd in the vicinity of the junction.

The Applicant does not propose to have any pipeline-related facilities at Arctic Red River. However, the community will have easy access to the right-of-way by river in summer and by the Dempster Highway the year round. Yet interaction is expected to be minimal, except in cases where community facilities such as the wharf and airstrip are used temporarily because of congestion at the pipeline facilities. Also, if more use were made of the Dempster Highway for movement of materials, interaction with the community would increase.

Considering the magnitude of construction, excavation and transportation activity in close proximity to the community, residents should have ample opportunities for short-term employment of an unskilled type over about a five-year period. As there are no locally based contractors, and only a small number of firms such as a retail establishment, it is unlikely that the attraction of labour to the pipeline will have any serious effect on local business. Although there will be two compressor stations, two communications towers, and a large airstrip in close proximity to the community, related operational and maintenance services will take place from Divisional Headquarters at Inuvik, and so they will not strongly affect Arctic Red River. Logistics, site preparation for camps, compressor stations and other facilities, and construction and clean-up are scheduled from 1975 to late 1980. No construction schedule is shown for the compressor station just west of the Mackenzie crossing.

Highlights

There will be little pipeline-related activity at Arctic Red River itself, but the community will be fairly close to sites that will be very active during construction. Of particular significance may be the Mackenzie River crossing 10 miles downstream. Generally, the pipeline project will have

some impact on Arctic Red River through the employment of local labour, occasional visits of construction personnel to the community and local residents of the pipeline site, and perhaps some disturbance to local hunting, trapping and fishing. The sum of these effects is not expected to be large nor beyond the community's ability to deal with.

5.4 FORT FRANKLIN

Fort Franklin is a Native settlement on the southwest shore of Great Bear Lake near the mouth of Great Bear River. Population was reported as 340 in 1971 (Lu and Mathurin, 1973) and as having increased to 404 in 1974 (Community Data, NWT, 1974). The labour force in 1974 has been estimated at approximately 100 (80 men and 20 women).

Hunting, trapping, fishing and handicarafts continue to provide the local economic base. In recent years a few residents have been drawn into seasonal wage employment such as forest-fire fighting, petroleum exploration, and big-game guiding. Average earned income for Native workers from all sources was about $1,000 in 1969-70. Although incomes have improved somewhat since then, it is likely that family incomes are still among the lowest in the Study Region and would probably range from $1,800 to $2,500. Social assistance caseloads, and payments of assistance for economic reasons, have shown an upward trend during recent years (Gemini North, 1974, Vol. 2, Sect. 7.4).

Community infrastructure and facilities include: trucked water and garbage; wharf and barge services; an airstrip and non-directional beacon; a volunteer fire department; churches; a skating rink; and cabin accommodation for visitors. Government services and facilities include: a nursing station; a post office; a school and library; and a game officer. Retail and commercial facilities are minimal, but include general stores and a fur trader; a craft shop; and a small general contractor. There are elected settlement and Band Councils.

The Native people hunt, trap and fish northward along Great Bear Lake and into the Whitefish River drainage basin, as well as along the Great Bear River and southward into the Johnny Hoe River drainage and westward towards Blackwater Lake.

Impact Assessment

The Applicant does not propose to use Fort Franklin's limited facilities or infrastructure, since the pipeline route will be about 65 miles to the west.

Two residents are already involved in the Applicant's training program and there should be additional opportunities as soon as more training positions are created. In addition, residents who are willing to move out of the settlement should be able to find employment in preparing a wharf and in stockpiling granular material and pipe at and near Fort Norman. There is also expected to be an increased demand for local handicrafts.

Highlights

Fort Franklin lies well off the pipeline route. Probably, the only way in which the community will become involved with the pipeline is by means of the employment of local labour during construction, and this could be quite minimal.

5.5 FORT GOOD HOPE/COLVILLE LAKE

Fort Good Hope is a predominantly Native settlement located on the east bank of the Mackenzie River near its confluence with the Hare Indian River in the Central Mackenzie Sub-region. Population

in 1971 was 325 (Lu and Mathurin, 1973) and in 1974 was 421 (Community Data, NWT, 1974).

The labour force was estimated at 57 in 1969-70, but this was a conservative figure and recently has been placed much higher. Estimates of the present labour force differ; however, an estimate of 130 persons seems reasonable, consisting of 80 Native men and 30 Native women, and 15 non-Native men and 5 non-Native women.

Main activities of local residents currently consist of: government and community services; petroleum exploration and highway construction; and hunting, trapping and fishing. Only about one-third of the labour force is employed for periods approaching full-time, and most of these people work for wages. However, there is only a small number of full-time hunters/trappers. About one-third of the labour force is employed seasonally for periods varying from 4 to 35 weeks. The remaining third is unemployed or seasonally employed to some minor extent.

Annual average income of wage earners was reported at about $1,800 in 1969-70 (MPS, Vol. 6). Although petroleum exploration and highway construction have improved wage rates, average family income is still less than in the Native settlements of the Mackenzie Delta. Native families that derive their income mainly from wage employment in 1974 probably have incomes in the $3,000 to $4,500 range.

Although more than 20 resident workers took employment outside the settlement in 1973, seasonal unemployment remains high. Social assistance caseloads have remained relatively static from 1968-69 to 1972-73. However, annual costs of assistance for economic reasons have quadrupled over that period (Gemini North, 1974, Vol. 2, Sect. 7.4).

The main government and community services include: a nursing station; a school; welfare services (a resident welfare aide and a visiting social worker from Inuvik); RCMP; a post office; a wharf and a barge service; an airstrip; a winter road; hydro; CN telecommunications; trucked water and sewer; a fire department (volunteer); churches; and a community hall and skating rink. Local commercial and retail enterprises include: a general store and fur trader; a general construction firm; and fly-in banking service from Inuvik. There are elected settlement and Band Councils.

Fort Good Hope can be typified as a Native community that has had a long and historic contact with the fur trade. In recent years it has been largely bypassed by development, and there has been only slight growth of the community during the past two decades; out-migration has occurred. Although there is suitable land for future expansion (Makale, Holloway and Associates, 1970), community infrastructure would need considerable investment to bring it up to suitable standards. The Native population's seasonal participation in hunting, trapping and fishing is still considerable, and income in kind is an important component of total income. The Native people's resource area extends along the Mackenzie Valley, westward up the Ramparts and Hume River basins, and northwesterly up the Hare Indian River into the Carcabou Lake area.

Colville Lake is a small Indian settlement of some 50 people located on the southeastern end of Colville Lake, about 80 miles northeast of Fort Good Hope. There are family links between the settlements and frequent travel from one to the other. The residents depend almost entirely on hunting, trapping and fishing. It is comparatively isolated, has almost no community facilities or services, and government services are supplied from Fort Good Hope. The labour force is small and has had little experience in work related to pipeline activities, but the general increase in development could bring increased business to the Colville Lake fishing lodge.

Impact Assessment

The Applicant plans to build a number of facilities in or near Fort Good Hope including: a construction camp, upgrading of the wharf, a materials stockpile, a communications tower, and a helipad. Two borrow pits very close to the community are identified as sources of 244,000 cu yd of aggregate which will be required for this purpose. About 22 miles downstream there will be a wharf, 4 miles of permanent road, a compressor station and a stockpile, a communications tower, two borrow pits, and 9.5 miles of temporary road, which would require a further 370,000 cu yd of material. In addition, because the pipeline right-of-way upstream of Fort Good Hope is some distance from the Mackenzie River (across a mountain), logical access to the construction campsite and the various facilities would be via the Mackenzie Highway (or a winter road) from Fort Good Hope. The work on the wharf, airstrip, camp and stockpile, and constant movement of crews and materials through the community would produce a marked physical impact.

There will be substantial short-term employment opportunities of an unskilled nature available to the settlement during pipeline logistics build-up, mainline construction, and compressor station construction. Logistics build-up should occur early in 1975; and site preparation for the compressor station at M-06 is scheduled for September 1975, with completion of construction scheduled for November 1978. Completion of the compressor station at M-07 is scheduled for November 1980. As about 20 members of the local labour force are now employed in petroleum exploration work, some of these people probably will enter pipeline-training and employment programs and be employed at semi-skilled and skilled jobs during construction. While there are two compressor stations and four communications facilities within a relatively short distance of the community, maintenance employees for these facilities are scheduled to be located at Norman Wells.

A town planning report (Makale, Holloway and Associates, 1970) indicates that there is adequate serviceable land around the settlement for modest residential, commercial and institutional expansion. Provided that the Applicant takes future community needs for land and granular material into account in planning his facilities, his requirements should not affect future community needs.

Highlights

Construction of the pipeline will have considerable impact on Fort Good Hope as the Applicant plans to locate a number of facilities related to the construction program at the community, and the pipeline right-of-way will pass within a few miles of the community. Impacts therefore will be experienced in a variety of ways including use of potential community lands, employment of local labour, purchases of goods and services in the community and perhaps some interference with local hunting trapping and fishing. Following completion of the pipeline, local activity should return to its present low level because the community does not figure into the Applicant's plans for pipeline operation. Because the community has not changed much throughout its more recent history, there is some question of the ability of Fort Good Hope to absorb the kinds of impacts the pipeline will generate.

Unlike Fort Good Hope, Colville Lake will experience minimal, if any, effects from the pipeline. These would occur entirely from the employment of some workers from the community.

5.6 FORT LIARD

Fort Liard is a predominantly Native settlement on the Liard River near the junction of the Liard and Petitot Rivers. In 1971 the population was estimated at 215 (Lu and Mathurin, 1973); in 1974 it was reported as 313 with the labour force estimated at about 70 (Community Data, NWT, 1974).

During recent years, the basis of the local economy has been employment with the petroleum industry; highway construction; fire suppression; hunting, trapping and fishing; and employment in local services. Most work and activity tends to be of a seasonal-casual nature.

Average income for individual wage earners in 1969-70 was about $1,400 (MPS, Vol. 6). Family income for Native residents currently may be in the $2,500 to $3,500 range. Social assistance payments for economic reasons have increased in the Fort Simpson welfare district which includes Fort Liard, but how much of this is attributable to this community is unknown. However, there is reason to believe that there has been an increase in the incidence of social assistance (Gemini North, 1974, Vol. 2, Sect. 7.4).

The main government and community services include: a nursing station; a school; an RCMP post; electricity; a wharf and barge service; an airstrip; a post office; a community hall and skating rink; etc. Infrastructure and housing are not modern and retail and commercial facilities minimal. However, there is good terrain available for expansion should the need for it arise.

The people of Fort Liard use the surrounding area for hunting, trapping and fishing. Areas that are used more than others include the valley of the Liard River and the small watersheds that empty into this river, for example, the Kotaneelee and Petitot Rivers.

Impact Assessment

The Applicant does not plan to build any new facilities or use any of the existing facilities at the community. However, if the Applicant were to use the Liard River for barge transport of pipeline materials,there could be some minimal direct effect on the community.

The Fort Liard labour force has had some experience with petroleum exploration and pipeline work, having participated in the Pointed Mountain project. It therefore should be able to respond to employment opportunities arising out of the proposed pipeline. Skill levels and experience are not particularly high, however, and employment available to Fort Liard residents likely would be of an unskilled, short-term nature.

The pipeline generally will lie to the east of the lands used for local hunting, trapping and fishing. The settlement could benefit from the sale of piles, skids, etc. required for pipeline construction and for construction work at Fort Simpson. Again, local people have some experience in forestry, and timber is one of the major potential resources of the Liard valley.

Highlights

The pipeline does not pass near the community of Fort Liard, so it would have little local impact. Some indirect effects could be experienced as a result of the employment of local labour during the construction phase.

5.7 FORT MCPHERSON

Fort McPherson is a predominantly Native settlement on the east bank of the Peel River, 24 miles from its junction with the Mackenzie River. The population in 1971 was 695 (Lu and Mathurin, 1973), and by 1974 was 761 (Community Data, NWT, 1974). The reported labour force in 1969-70 was 115 (MPS, Vol. 6), but this was probably understated; the labour force in 1974 is estimated at about 200, consisting of 135 Native men and 40 Native women and 15 non-Native men and 10 non-Native women.

Local employment has been based on construction activity, consisting of community development in the early 1970's, and the Dempster Highway in 1972 and 1973; hunting and trapping; petroleum exploration outside the settlement; government and community services; and occasional lumbering based on local forest. The community used to rely heavily on income in kind derived from hunting, trapping and fishing, but in recent years wage employment has become the main source of income.
The younger members of the labour force have made a significant adjustment to employment in petroleum exploration and highway construction. At the height of the 1973 employment season, about 40 men and 8 women were working at various jobs away from the community.

Annual average income of wage workers was reported at about $2,400 in 1969-70 (MPS, Vol. 6), and has since probably improved. Social assistance caseloads and assistance for economic reasons have declined during the past four years (Gemini North, 1974, Vol. 2, Tables 7.15 and 7.13). Considering all factors, a reasonable estimate of average annual income for wage-employed Native families in 1974 would be in the order of $4,000 to $5,000.

Community and government services and facilities include: a nursing station; a school and hostel; RCMP and a justice of the peace; a resident welfare aide as well as regular welfare services out of Inuvik; a post office; piped or trucked water; electricity; a wharf and barge services; a landing strip and regular air service; the Dempster Highway which is currently under construction; a community hall; churches and fly-in banking services from Inuvik. Retail and commercial firms include general stores and fur traders, trucking contractors, and a construction contractor. Any significant increase in population would require the upgrading and installation of facilities such as sewer and water, electricity, roads, etc. There are elected settlement and Band Councils.

Native people make extensive use of the surrounding area for hunting, trapping and fishing. Use is made of the Upper Mackenzie Delta, the lowlands to the east including the Arctic Red River Valley, the Peel River for a considerable distance, and the Richardson Mountains to the upper reaches of the smaller tributaries of the Porcupine River system. Caribou are taken on the eastern slope of the Richardsons, from the Rat River up to the Vittrekwa River. Dall's sheep are taken in the mountains.

Impact Assessment

The Applicant proposes to have a material stockpile at Fort McPherson. There will be access by river to where the right-of-way crosses Peel River, five miles downstream. The Dempster Highway also will provide access to the pipeline. In the vicinity of the river crossing will be: a wharf, a material stockpile, a construction camp, two helipads, a block valve, and access roads to borrow sites. These facilities and the permanent access road will require 340,000 cu yd of granular material. A further 145,000 cu yd will be required for material stockpile at Fort

McPherson but the Applicant has not indicated the source of this material.

Pipeline-related activity at Fort McPherson itself, at the Peel River crossing and along the mainline right-of-way, should provide opportunities for considerable short-term unskilled employment. Access to the Richards Island segment of the pipeline via the Dempster Highway should allow Fort McPherson workers to participate in pipeline-related work for at least the duration of construction. Logistics, site preparation, and various construction activities are slated to begin in late 1975 in the case of the compressor station to the east, and would extend to July 1979 when the compressor station to the north is to be completed. Local residents might also participate in longer term construction, but those who did would probably have to work out of Inuvik.

Activity associated with stockpiling at Fort McPherson would produce some impact on community services and accommodation, particularly if pipe or materials were transported to Fort McPherson or other communities from the Yukon. Provision of borrow materials and local production of forest products such as skids at construction sites could be beneficial to local contractors. However, such activities could also threaten reserves required for community use.

A general increase in business activity is likely to stimulate the expansion of local service and retail establishments. Pressures on housing, schools and RCMP services are likely to increase.

The pipeline route along the east flank of the Richardson Mountains parallels a caribou migration route and would be frequented by residents during the hunting seasons. Moreover, the Fort McPherson trappers would need to cross the right-of-way to gain access to traplines in the Delta.

Highlights

The pipeline project will have considerable impact on the community of Fort McPherson. In terms of direct effects, construction of the pipeline will generate a substantial amount of activity at the town and in the immediate area. There could be some effect on trapping, hunting and fishing. Less directly, the pipeline project will probably offer employment to a significant proportion of the local labour force. One factor that must be kept in mind is that the impact in the community will be relatively short-lived. The Applicant does not intend to base permanent staff there and his commitment to the community will be short-term in character. Care will have to be taken to ensure that the disturbances that occur during pipeline construction are not of a kind which would permanently impair the community's ability to function.

5.8 FORT NORMAN

Fort Norman is a settlement located on the east bank of the Mackenzie River, immediately above its junction with Great Bear River. It is about 45 miles south of Norman Wells and has a 4,400-ft airstrip. The shoreline of the community is the only suitable location for a barge dock for many miles along the Mackenzie (O.L. Hughes, 1974, pers. comm.).

Population in 1973 was estimated at 280 people (236 Native people and 44 "Others"), which indicates some growth over the 1971 population of 250 (Lu and Mathurin, 1973). Total labour force has been estimated at about 115 in 1973, including 72 Native men and 24 Native women and 12 male and 7 female non-Natives (Community Data, NWT, 1974 and pers. comm., 1974).

The principal sources of employment are: government and community services; hunting, trapping and fishing; and oil exploration and construction work.

Government employment is small, but stable. Other wage employment in exploration and construction work is growing in importance, but is seasonal. Lately, some Fort Norman residents have been employed on the Mackenzie Highway. A number of the older residents can be considered full-time hunters and trappers, and most residents turn to local game and fur rerources for meat and supplementary cash income.

Estimated average income in 1969-70 for the settlement's 39 Indian families was $3,382, and for 6 Métis families was $4,863; however, wage rates have increased since then (chiefly due to seismic and construction work) and a reasonable range for Native family income in 1973 would be from $3,800 to $5,500.

There is minor unemployment in the community in summer, and considerable unemployment and underemployment in winter. Average monthly social assistance caseloads have declined over the past five years (from 14 in 1968-69 to 9 in 1972-73), but because average payments per case have increased, total costs of social assistance have risen slightly (Gemini North, 1974, Vol. 2, Sect. 7.4).

Community retail and commercial enterprises include: a Hudson's Bay store and post office; a small hotel and restaurant; regular air services; CN telecommunications; a small transport contractor; a winter road; and periodic travelling banking services out of Inuvik. Government services consist of: a school; nursing station; library; RCMP; periodic welfare services out of Norman Wells; docks; airstrip; and various forms of public housing. Community services and facilities include: trucked water and sewage disposal; churches; a community hall; and a fire department. There are elected settlement and Band Councils.

The settlement can be typified as a moderately isolated Native community which has seen little change over the years. Because of the location on a terrace between the airstrip and the banks of the Mackenzie and Great Bear Rivers, Fort Norman is somewhat limited with respect to high, well-drained land for development.

The use of adjacent lands for hunting, trapping and fishing is extensive. Trapping and hunting extend up the Mackenzie River and laterally up the valley of the Keele, Redstone, and Saline Rivers. Other main hunting and trapping areas include the Brackett and Mahony Lake areas to the north (across the Great Bear River), and eastward along the north bank of the Great Bear to the vicinity of St. Charles Creek.

Impact Assessment

The pipeline will be only about 4 miles from the community and the Applicant intends to use Fort Norman as a major staging point for transferring pipe and supplies from river transport to land and air transport. A number of facilities therefore are planned within four miles of the settlement. These include: a materials stockpile; wharf construction and upgrading the airstrip; a communications tower; and a block valve, two helipads, and access roads from the block valve and helipads. Sources of the borrow material required for these facilities have not been identified.

In addition, there would be two construction camps, each located about 27 miles from the settlement (M-09 to the north and M-10 to the south). Construction work from these camps would be carried out during the winter of 1977-78. The camps would include: a communications tower, a helipad, a compressor station, stockpile, and borrow pits. The northern compressor site would require 330,000 cu yd and the southern site 450,000 cu yd of aggregate.

There would be substantial short-term employment opportunities in clearing the right-of-way and removing borrow material, as well as in construction

work during the logistics build-up phase, mainline construction phase, and during compressor station construction. Logistic activity would begin in 1975 and preparation of the compressor site south of Fort Norman early in 1976; this station would be completed in November 1978; the compressor station north of the community would be completed by the end of 1980. At present two men are involved in the Northern Training Program being conducted by the Applicant and as the Program expands there should be opportunities for additional residents to obtain training for semi-skilled or skilled jobs. However, prospects for long-term employment in Fort Norman itself are not very good. Present plans indicate that maintenance and operation of the two compressor stations and three communications towers will take place from Norman Wells.

Location of the stockpile and wharf at the community, and movement of workers by means of the local airstrip to nearby work camps would result in virtually continuous contact between pipeline workers and local residents. The hauling of heavy construction materials either through the settlement (if the present wharf is used), or at one end of the settlement (if a new wharf is built at the east end), would have serious implications for the safety of residents and the integrity of the community's roads. In addition, the pipeline will pass through local hunting and trapping areas, which could raise problems because of the extensive use that is made of hunting and trapping resources.

Highlights

As matters are planned at present, construction of the pipeline will have a major impact on Fort Norman. This impact will occur in several ways: local facilities will be expanded and used for logistic support to construction; local labour will be employed in construction; transients will move through the community, and the pipeline could have some effect on local trapping and hunting. Following the end of construction, local activity probably would return to its present low level, since the community is not envisaged in the Applicant's plans for pipeline operation. The foregoing could have serious consequences because as a small and insular community Fort Norman has had little past experience which could prepare it to handle major change.

5.9 FORT PROVIDENCE

Fort Providence is a predominantly Native settlement located on the north side of the Mackenzie River just off the Yellowknife Highway and ferry crossing. Its population in 1971 was 595 (Lu and Mathurin, 1973) and currently is about 635. The labour force is reported as 155 people; there are about 62 male and 21 female Indian workers and 47 male and 25 female non-Indians (pers. comm., 1974).

The local economy is based on employment in government and community services, road construction and maintenance, forest-fire fighting, commercial fishing and tourism. Hunting, trapping and domestic fishing are important to the Native people. There is some marginal agriculture northwest of the settlement in the Horn River valley.

About one-third of the labour force works for wages for much of the year, about one-third is engaged mainly in seasonal wage employment, and the remaining third is either active in hunting, trapping and fishing, or idle for much of the year.

The average annual income of Native people who worked mainly for wage employment was about $2,000 in 1969-70 (MPS, Vol. 6); Native families who depend on wage employment currently would have incomes ranging from $2,500 to $3,500. There is considerable unemployment in the community, although government work projects such as Hire North have tended to alleviate this during recent years.

Average monthly social assistance caseloads declined slightly between fiscal years 1968-69 and 1972-73, although for economic reasons, annual social assistance payments increased substantially (Gemini North, 1974, Vol.2, Tables 7.15 and 7.13).

Services and facilities are reasonably complete and include: trucked water and garbage disposal; a wharf and barge service; highway access; an airstrip and community-based aircraft; churches and a community hall; an outdoor swimming pool and a skating rink. Government services include: a nursing station; schools and hostels; welfare services; electricity; a post office; and CN telecommunications. Retail and commercial enterprises include: general stores and a fur trader; accommodation, meals and lounges; banking; air charter services; and transport and automotive services. There are elected settlement and Band Councils.

The community infrastructure is reasonably adequate, but is not modern, nor could it be easily expanded. Accommodation is in short supply, but land is available for community expansion. The labour force has outgrown local employment opportunities; however, some of the seasonal slack is absorbed by hunting, trapping and fishing. The Native people make extensive use of the land, and the main hunting/fishing areas include the Mackenzie Valley, Mills Lake, the Horn River and its tributaries, and the Horn Plateau.

Impact Assessment

Fort Providence is a considerable distance from the pipeline right-of-way, as well as from communities such as Hay River and Fort Simpson that will bear the main brunt of pipeline development, but it is on the barge route of the Mackenzie River system. The Applicant does not plan to build facilities at or near the settlement, or to utilize existing community facilities or services.

The pipeline could provide substantial employment for Fort Providence residents. There is an oversupply of local labour, there is easy access to the high-impact communities by road or air, and many local residents are relatively mobile and experienced at various occupations. It is likely that local people who choose to work on the pipeline will mainly undertake short-term unskilled employment such as building wharves, operating borrow pits, and clearing right-of-way.

The community makes considerable use of the Mackenzie River and nearby watersheds for hunting, trapping and fishing. Increased river and perhaps highway traffic that will pass by the community during pipeline construction may have some effect on these activities.

Highlights

Fort Providence lies well off the pipeline route and the pipeline therefore will not affect the community directly. However, some local people will undoubtedly work on pipeline construction. Increased traffic on the Mackenzie River and Highway during construction could have some negative effect on local hunting and trapping.

5.10 FORT SIMPSON

The village of Fort Simpson is located on the Mackenzie River immediately downstream of the confluence of the Mackenzie and Liard Rivers. It is 273 miles by road from Hay River along the Mackenzie Highway. Estimated population in 1971 was 745 (Lu and Mathurin, 1973), and it was reported to have increased to 1,200 in 1973. There are about 700 Indians and Métis and some 500 non-Native people in the community. The resident labour force numbers about 400, which includes about 375 men and about 25 women (pers. comm., 1974).

The population has a large youth component. Natural increase within the Native group is relatively high, and reasonably steady increases in the resident labour force can be anticipated. A number of transients have worked in the area intermittently, chiefly in mineral exploration and highway construction. These people numbered in the order of 100 to 175 persons at any given time during peak activity periods in 1972 and 1973. Concurrent with the completion of the Mackenzie Highway to Fort Simpson and the recent increase in petroleum and mining exploration in the area, some southern transients have arrived in the community in search of work. This has raised some local problems.

The local economy has been strongly influenced by two recent factors—the strategic location of the community with respect to transportation, and the community's service function in terms of activities such as mineral exploration and highway construction. The growth of government and community services has also been important. Of continuing though lesser importance are activities such as hunting, trapping and fishing, a small tourist industry, and some exploitation of the forest resource of the surrounding area.

Generally, employment related to transportation activities such as river barge operations, highway construction and maintenance, ferry operation and winter road operation is seasonal. Operation and maintenance of the community's airports is an exception to this pattern. There recently has been considerable institutional, residential, and commercial construction during summer months. Employment deriving from government and community services tends to be stable and year-round. Fire fighting can be a large employer of Native people during the summer, but this of course varies greatly from year to year. Employment in hunting, trapping, fishing and forestry is of a seasonal nature. To some degree, these industries function as a secondary source of income when wage employment is scarce.

Resident Native families whose main source of earnings is wage employment have an annual income of between \$4,500 and \$7,500. Resident non-Native families have annual incomes of from \$7,000 to \$11,000 (MPS, Vol. 6). The fact that they tend to be employed only seasonally would account in part for the fact that the incomes of Native people are lower than those of non-Natives. Less access to jobs requiring higher skill levels is another factor. To some extent, the lower cash incomes received by Native people are offset by income in kind derived from hunting.

Nevertheless, there has been a relatively high demand for labourers in the Fort Simpson area from 1971 to 1973, particularly during the summer months. During the winter, the Hire North highway employment project tends to modify the effects of seasonal unemployment, even though such unemployment still remains a problem.

The incidence of overall social assistance in the community has declined slightly over the past five years, even though social assistance payments for economic reasons have risen sharply (Gemini North, 1974, Vol. 2, Tables 7.15 and 7.13).

Community retail and commercial enterprises consist of general retail, hardware and clothing stores; general contractors; trucking firms; a service station; a theatre; scheduled and charter air services; banking; and restaurant facilities. The main government services and facilities include schools, library and education services; hospital and medical services; welfare services; a game officer; RCMP and a justice of the peace; a post office and telecommunications facilities; electricity; a large liquor store; a major airport ferry services across the Liard River; and various forms of public housing. Community services and facilities include churches; a piped sewer and water system; a community hall; a skating rink; tennis courts; a baseball diamond; a temporary swim-

ming pool; a volunteer fire department; and a village airstrip. There are elected village and Band Councils.

Because Fort Simpson is situated on a small island, there are emerging problems of available land for development, as well as associated problems of water supply, sewage disposal and roads.

Future growth of the village and traffic or construction activity would have implications for residents who make day use of hunting and trapping resources. Native people trap along the Mackenzie and Liard River valleys that radiate in three directions from the village, as well as in the lowlands to the west, which include such watercourses as the Martin and North Nahanni Rivers. There is also some hunting and trapping to the northeast up the Rabbitskin River towards the Horn Plateau, to the southeast towards Trout Lake, and to the west towards the Mackenzie Mountains, where local hunters go in search of woodland caribou and Dall's sheep.

Impact Assessment

The Prime pipeline route crosses the Mackenzie River about 40 miles downstream from Fort Simpson. At this point, facilities on the north side of the river include a wharf, a materials stockpile, and a borrow pit. On the south side of the river will be located a block valve and helipad. At site M-15 there will be a construction camp, a materials stockpile and a compressor site, a helipad, a communications tower, two borrow pits, and a 10-mile permanent road from M-15 to the Mackenzie Highway. The distance from M-15 by all-weather road to Fort Simpson will be approximately 25 miles, of which 15 miles will be along the Mackenzie Highway. The pipeline will cross the Liard River about 33 miles upstream of Fort Simpson at Pipeline Mile Post 700 and the Liard Highway at about Pipeline Mile Post 705 where there is to be a materials stockpile.

From the Liard Highway there will be 11.5 miles of permanent road to site M-16 (Pipeline Mile Post 716). At M-16 will be a construction camp and compressor site, a communications tower, a helipad and a borrow pit. Between the Mackenzie River crossing and M-16, there will be 14 borrow pits associated with the right-of-way or other pipeline facilities. Borrow material requirements for M-15 and its access road will be 780,000 cu yd of material, and for M-16 and its connecting road, 600,000 cu yd of material. In addition, there will be further aggregate materials required for communications towers, the block valve, and various helipads, as well as the two stockpiles at Pipeline Mile Posts 644 and 705.

Increased requirements for transportation will affect employment at Fort Simpson from the very beginning of pipeline logistics activity. Logistic activity would begin in 1975 and remain at a sustained level until all aspects of construction were completed for the entire development. The start on site preparation for compressor station M-15 is scheduled for late 1976 with completion of construction in late 1980; work on M-16 falls between January 1977 and July 1979. Thus there should be considerable short-term employment of an unskilled nature available to Fort Simpson residents for at least five years. Moreover, because Fort Simpson is to be a District Headquarters and operation and maintenance centre, there will be 60 to 70 long-term jobs located in the community.

Local contractors may have the opportunity to bid on contracts for borrow materials, wharf building, pipe hauling, etc. The retail and service sector of the settlement also should receive some stimulation during the construction phase as Fort Simpson will be a service stop for truckers and the airport will be a transfer point from large to smaller aircraft for construction workers employed in nearby camps. The fact that Fort Simpson has

been selected as one of the Applicant's Divisional Headquarters is of considerable significance to long-term community growth.

Pipeline-related activity will create pressure on community and government services. Additional use will be made of local medical and dental services, although the Applicant intends to supplement these activities as required. The same assurances are made in the Application with respect to housing for staff, water and sewer facilities, electricity, etc. (Sect. 13.b.2.2). However, it is not clear who is to be responsible for the housing and associated services required to accommodate population increases related to construction activity. Moreover, accommodation will be required for those working for the Applicant's contractors.

Marked growth in resident population and commercial expansion would require the servicing of additional land and upgrading of all community infrastructure (Francl and Associates, 1974b). The pipeline could generate a substantial volume of highway traffic, and probably would require an expansion of ferry services across the Liard River.

Fort Simpson has undergone a significant increase in problems such as alcohol abuse and juvenile delinquency in recent years (Village justice of peace, 1974, pers. comm., and Gemini North, Vol. 6 Ch.II). If the present social problems do not improve, increased local expansion and population growth caused by pipeline development could aggravate the situation.

While at least half of the population continues to be of Native extraction, non-Native businessmen and government officials currently dominate the village council and local decision-making, a fact which tends to produce some ethnic discord. An influx of population from the South is not likely to improve this situation.

Highlights

Fort Simpson has grown rapidly during recent years with activities such as construction of the Mackenzie Highway and logistic support to oil and natural gas exploration. The level of social problems and discord among Native and non-Native groups also has increased. The pipeline project will have a prolonged and varied effect in the community. During construction, the community will serve as a source of labour, a staging and highway-barge trans-shipment point, a source of supplies and services and perhaps a place to which crews that are not directly under the Applicant's control will come for entertainment. During operations, the fact that Fort Simpson has been designated as one of the Applicant's operating and District Headquarters could have a stabilizing effect on the long-term growth of the village. Nevertheless, there are serious questions as to the community's ability to adjust to further change without large increases in the levels of alcoholism, juvenile delinquency and inter-ethnic conflict. Great care will have to be taken to ensure that the pipeline is not too disruptive an influence in the lives of the community residents.

5.11 HAY RIVER

The town of Hay River is located on the shore of Great Slave Lake at the mouth of the Hay River. It is the northern terminus of the Great Slave Railroad, the southern terminus of the Mackenzie River water transportation system, and a major northern air transportation centre with a 6,000-ft paved airstrip and non-directional beacon. The community consists of the "new town" which is on the west bank of the Hay River about two miles above the river mouth, as well as the "old town" which consists of a number of delta islands and the Indian village on the east bank of the Hay River.

The 1971 population of Hay River was estimated at 2,400 (Lu and Mathurin, 1973) and in 1974, it was 3,500 (Community Data, NWT, 1974). It is predominantly a non-Native community; Native population in 1971 was 575, and currently may be around 625. The resident labour force was estimated at 502 in 1969-70, consisting of 114 Natives and 388 non-Natives (MPS, Vol. 6). A recent report from town officials indicates a current resident labour force of 500 men and 200 women. The number of transient workers employed during the summer transportation and construction season is unknown, but may reach more than 300 at the height of the season.

The average income of non-Native wage earners in 1969-70 was about $4,900, and for Natives it was about $2,200 (MPS, Vol. 6). Since then, incomes have increased markedly in this community. Considering that many families consist of more than one income earner, a reasonable current estimate of non-Native family income would be $6,000 to $9,000. Among Native people, family income from wage employment would fall into the $3,500 to $6,000 range.

The large and well developed transportation sector, the community retail and service sector, the general construction industry, and government and community services provide much of the community's employment base. Hay River is the main base of the Great Slave Lake commercial fishery. Fishing is also undertaken for domestic purposes, and there is some hunting and trapping in the area.

Apart from renewable resource harvesting, all sectors - particularly transportation and construction - are expanding rapidly. Community infrastructure is modern and extensive. Favourable climatic, soil, and locational factors make Hay River a suitable place for future growth. Accommodation is currently in short supply, but there is reasonably good terrain for expansion. Although permafrost can cause some construction problems, these are less severe and less widespread than in more northerly communities, and local services such as sewer and water generally can be installed by use of conventional techniques.

There are a variety of commercial and retail establishments in Hay River, and these have undergone a substantial expansion during recent years. Unlike many other northern communities, much of the growth stimulus in Hay River has come from the private sector instead of government even though the latter is important. With its relatively large and experienced work force and well developed community infrastructure, Hay River is a likely place for the establishment of small-scale manufacturing operations designed to cater to the Mackenzie Valley market.

The Native population lives mainly in a separate settlement across the east channel of the Hay River from the old town. Native people are seasonally and permanently active in wage employment, although some continue to hunt, trap and fish. Hunting and trapping areas include: upstream sections of the Hay River drainage basin, eastward into the Buffalo Lake drainage area, and westward into the Tathlina/Kakisa Lakes area.

Impact Assessment

During the logistics build-up and construction phases of the pipeline project, the impact on Hay River will be substantial, perhaps greater than in the case of any other Study Region community. The transportation, construction, and small-scale manufacturing industries of the community could expand rapidly. Other sectors such as commercial services and retailing, as well as community and government services, would likewise be affected, although perhaps not quite as directly.

The Applicant indicates that 1,520,000 tons of pipeline material will be shipped northward from Hay River by barge, and another 314,000 tons by

truck, for a total of 1,830,000 tons (Sect. 13.a.3. 4., Fig. 6). The town's airport also will be the scene of major trans-shipment activity.

The Applicant expects that railroad trans-shipment activity will create 25 man-years of employment annually over four years. Barge activity should have a much greater employment effect, creating 375 man-years of employment annually between 1976 and 1979 (Sect. 14.c, Table 4.5). It is likely that the majority of this will occur in Hay River. The stockpile sites from Pipeline Mile Post 644 (where the line will cross the Mackenzie River) to about Pipeline Mile Post 790 are to be supplied by truck. This will require about 60 man-years of employment annually during 1975 and 1976 to man the estimated 30 tractor-trailer units which will operate out of Hay River, in addition to employment in stockpiling and warehousing activities (Gemini North, 1974, Vol. 4, p.164 and Vol. 3, p.56).

There will be a substantial volume of construction in the community. This will include: a major stockpile and trans-shipment site - probably at Enterprise, south of Hay River; expansion of wharf facilities; warehouses at the stockpile, the marine installations, and at the airport; industrial facilities related to transportation and pipeline development - for example, those required for bridge fabrication, manufacture of cement products, etc.; and construction related to population increases - housing, sewer and water, streets, etc.

Population increases probably would mean an expansion of commercial, community and government services. Institutional facilities such as schools and hospitals would require additions. The Applicant intends to use existing hospital centres for the treatment of seriously ill or injured workmen during both construction and operation of the pipeline. This would have implications for Hay River medical and dental personnel and for the local hospital.

The major materials stockpile and trans-shipment yard at Enterprise would have to be built before any other pipeline logistics could proceed, and would continue in use well into the operation phase. The Applicant does not indicate that he would develop and operate this facility, and probably the work would be contracted to a transportation company. However, borrow materials, warehouses, a labour force,etc. would be required and much of this will be drawn from the Hay River area. The Applicant makes references to the double jointing of pipe (Sect. 13.a.6.4.6), and to applying an anti-corrosive coating (Sect. 13.a.6.5.11); these activities would draw on Hay River for facilities and labour.

Population expansion likely would be accompanied by a shortage of accommodation, pressures on serviceable land, and a substantial investment in local infrastructure. Pressure for commercial and residential land also could be felt by the Native settlement across the river from the old town. Speculative transients from the South would have ease of access to the community by road and air, and this could become a problem.

Native people should have an opportunity for seasonal employment in activities related to pipeline development (mainly river transportation) for a five-to seven-year period. Construction activities on the pipeline right-of-way or activities related to transportation should not have a direct effect upon Native hunting, trapping and fishing.

Highlights

Hay River has grown rapidly during recent years, having attained some maturity as a transportation, commercial, and small-scale manufacturing centre. It has reached a stage in its development at which

many of the problems that other Mackenzie Valley communities are only beginning to encounter have already been dealt with quite effectively by this community. Nevertheless, the pipeline will impose new demands and pressures that the community will have to absorb during the entire pre-construction and construction periods. Commerce, manufacturing and transportation, particularly the last-named, will all undergo expansion. Population will increase and likely there will be pressures on serviced land and on community services. Accommodation could become scarce, and the number of speculative transients that the community may have to handle, because of its easy access from the South, could raise problems.

5.12 INUVIK

The town of Inuvik was begun as a planned government administrative centre for the Lower Mackenzie Sub-region in 1955-56. A population of 2,000 in the long term was envisaged, but in 1971 this was exceeded when the population reached 2,645 (Lu and Mathurin, 1973). By 1974, it was estimated at 4,150 (Community Data, NWT, 1974). Non-Native people are currently in a slight majority within the total population. Working-age population would be about 2,640 (Community Data, NWT, 1974). Of this, about 1,400 to 1,600 persons belong to the actual labour force; this would consist of perhaps 700 non-Native men and 300 non-Native women, and perhaps 300 Native men and 200 Native women.

The approximate average annual income of individual Native wage earners in 1969-70 was about $3,500. One source indicates that the equivalent figure for the non-Native population was about $6,500, but this is probably distorted downward by the small size of the sample from which it was derived (MPS, Vol.6). Inuvik has a select population structure which results in a high labour-force participation rate, and little unemployment for much of the year. Family incomes are the highest in the Study Region for both Native and non-Native people and multiple wage earners within a family are the rule. Family incomes for Native wage earners are probably in the $5,500 to $7,500 range; and for non-Natives in the $6,500 to $10,000 range.

Government services, general construction, the retail and service sector, seasonal petroleum exploration and development, and transportation provide the bases for employment in and around the community. Government services, retailing, and commercial services continue to provide the largest volume of employment, as well as being the most stable source of employment. Other activities are largely seasonal. To some extent seasonal employment is complementary; for example, the height of petroleum seismic work and well drilling is in mid-winter, while peak general construction and transportation activity occurs in summer. There are a few Native people who hunt and trap on a full-time basis, and a substantial part of the Native population participates in the spring muskrat harvest and in occasional hunting and fishing throughout the year.

The infrastructure and transportation facilities serving the community are comprehensive in scope, but varied in quality and capacity for expansion. Generally, transportation and communication facilities are of good quality and have sufficient capacity for expansion under normal circumstances. Serviceable land is a problem and sewer and water services vary greatly in quality. Office accomodation, fire department facilities, etc., are inadequate, and electricity is expensive. All forms of housing and accommodation are in short supply and, in the absence of immediate action, this problem can only worsen (Makale, Holloway and Associates Ltd., 1973a).

Inuvik has a reasonable variety of stores, specia-

lity shops, and financial institutions. Transportation and communication services and facilities are extensive. Particularly noteworthy are the variety of scheduled and charter air service, and barge and trucking companies.

General commercial services include local transport, catering and expediting, automotive services, a range of communication facilities, and fuel and utilities. For a town of a population of 4,000, Inuvik has a surprising range of small contractors and trades people, particularly firms associated with petroleum exploration, excavation, and trucking.

Government and community services and facilities are extensive. The major ones include a 100-bed hospital, 5 doctors and 2 dentists, comprehensive education and welfare services and facilities, a large RCMP detachment, a justice of the peace and detention facilities, a paved 6,000-ft airstrip and instrument landing system, CBC radio and television (including some local production),a large research laboratory, and a community hall and library.

There is also a variety of recreation services and facilities including a swimming pool, a ski club (cross country), skating and curling, athletic fields for summer sports, etc. Much of the recreation, however, appears to centre on special interests, and there seems to be a need for a vigorous, well-rounded approach to public recreation (Makale, Holloway and Associates Ltd., 1973b).

At the root of the town's development problems is rapid growth due to its position as a transportation and exploration centre, and its function as a centre for government and industrial administration. Pressures on accommodation, serviced land, etc. have produced a need for capital investment that is beyond the town's financial capability.

Native people make substantial use of the Mackenzie Delta and Husky Lakes area for hunting, trapping, and fishing.

Impact Assessment

The pipeline right-of-way will pass about 10 miles east of Inuvik. There will be access to the right-of-way via the Mackenzie Highway about 15 miles southeast of the town; by barge using the east channel of the Mackenzie River downstream at Swimming Point (approximately 50 miles by barge); and by air to Richards Island, Swimming Point, the Parsons Lake Junction, Parsons Lake, and to other helipads and airstrips around the Delta.

The Applicant proposes to construct a wharf, a materials stockpile, an operations and maintenance pad and centre, and a communications tower and helipad (with an associated winter road) near or within Inuvik. Between Pipeline Mile Post 90 and 100 there will be two borrow pits, a communications tower, a compressor station, a helipad, and a 1.5-mile permanent road to the Mackenzie Highway. Borrow material requirements in the vicinity of Inuvik will be 364,000 cu yd which may have implications for community reserves. There are additional needs for 320,000 cu yd for a compressor station, an access road and a helipad at about Pipeline Mile Post 94. Movement of stockpile materials and aggregate will have substantial impact on traffic, town roads, and the Mackenzie Highway.

With respect to employment, short-term demand for unskilled labour will be highest in the winter of 1976-77 and 1977-78; however, logistics and various construction activities are scheduled from 1975 to mid-1978 when the compressor station M-02 will be completed. Moreover, Inuvik is to be a Divisional Headquarters and an operation and maintenance centre for the pipeline; 70 full-time jobs are to be located at the community by the fifth year of

pipeline operation. In addition, it probably will be a marshalling point for construction workers for activities throughout the northern Study Region and perhaps also for some Alaskan parts of the pipeline. The movement of transient workers from southern Canada to various pipeline sites could cause a multiplicity of social and economic problems at Inuvik unless strict controls are worked out and carefully enforced.

Increased population arising from pipeline development will have a severe impact on all community and government services. In particular, accommodation shortages and related resources and services (suitable land, utilidor, roads, electricity, etc.) will be particularly affected. Most of the impact on local services and facilities will result from the relatively large short-term increase in the labour force located at or near Inuvik in connection with pipeline-related activities such as logistics, the development of borrow pits, and transportation. Increases also will take place in population related to the expansion of local business and public services due to the pipeline. Persons employed directly by the Applicant in connection with Headquarters and maintenance functions will not be large in numbers.

The Applicant states he will use the medical and hospital services at Inuvik (Sect. 13.b.2.2.2) for the treatment of industrial injuries to personnel located at Delta construction camps and for town-based personnel. Providing the Applicant carries out his intention to involve government in meeting his projected medical and hospital requirements, the extra demands of the pipeline probably could be met by the existing hospital (Sect. 13.b.2.2.2, b.7). However, an evacuation plan, additional medical staff, and perhaps some extra equipment likely will be needed.

The Applicant states it is his intention not to place additional pressure on existing facilities regarding larger communities such as Inuvik (Sect. 14.c.4.6.1); and that he will cooperate with government during the operation phase concerning additional requirements for public facilities such as sewer and water, power, roads, fire protection, and emergency health care (Sect.14.c.5.7). However, no mention is made of the Applicant's involvement prior to and during the construction phase. All such mentioned community infrastructure and services are now under pressure (Makale, Holloway and Associates Ltd., 1973b) and the anticipated population growth during the construction period requires immediate substantial capital investments and continuing operating costs.

Assuming an estimated town population of 6,000 to 7,000 by 1980, at which time mainline construction will have been completed, compressor station construction will be in progress, and pipeline operation will have commenced, the following projections of additional major government requirements have been put forward:schools, 25 classrooms; 757 dwelling units; other floor space, 200,750 sq ft (Makale, Holloway and Associates Ltd., 1973b); government staff, 38 (MPS, Vol. 1); and teachers, approximately 25.

The additional requirement for serviceable land is substantial, as are requirements for parks and recreation areas, roads, etc. However, no estimate is included because land use could be affected by such decisions as the formation of a satellite industrial town or making maximum use of multi-dwelling units.

Highlights

Inuvik will be affected by a variety of major influences during the next decade, development of the pipeline being only one of these, although a major one. It will be one of the most rapidly growing communities in northern Canada, and perhaps in all of Canada. Because it has already experienced ra-

pid growth, it must be viewed as reasonably well prepared for further growth. However, there will be problems such as the limited availability of serviced land, the already apparent crowding, social problems etc. Careful planning will be required if the town is to be able to continue to play its growing role as an administrative, logistic, and transient staging centre without undue friction. The fact that the town will become one of the Applicant's operating and district headquarters will add longer term stability to the local economy, but also will generate requirements for the expansion of facilities and services.

5.13 JEAN MARIE RIVER

Jean Marie River is an unorganized Native settlement located at the confluence of the Jean Marie and Mackenzie Rivers, about 38 miles southeast of Fort Simpson. Normal access to the settlement is by water and aircraft in the summer and by aircraft in winter. The community is about 15 miles from the Mackenzie Highway. Its population was 31 in 1971 (Community Data, NWT, 1972) and not quite 50 in 1974; the labour force in 1974 is estimated at under 20 persons (Community Date, NWT, 1974).

The community is dependent on hunting, trapping and fishing for food and cash income. The main local source of wage employment is the small portable sawmill operated by the Jean Marie Cooperative. The incidence of total welfare payments is understood to have risen slowly during recent years, but assistance payments for economic reasons may have increased considerably. Annual family incomes currently would average between $2,000 and $3,000, if all sources are considered.

Government and community facilities, although minimal, include a school and library; a wharf and barge service; electricity; CN telecommunications; a 1,400-ft airstrip; and a winter road to Fort Simpson. There are no local stores, no medical, welfare, or police services, and no water or garbage disposal services. The community looks after many of its own needs or relies on services out of Fort Simpson.

The Native people of the settlement hunt, trap and fish along the Mackenzie River, the Jean Marie River valley, and the valley of the Rabbitskin River. They use logs from the Mackenzie and Liard River valleys for their small sawmill.

Impact Assessment

The Applicant does not plan to build or utilize any of the facilities in the settlement of Jean Marie River.

The pipeline could generate some employment opportunities for local residents during the winters of 1975-76 and 1976-77, when construction would be in the general vicinity of the settlement. Employment would be mainly of an unskilled, short-term nature. There would be few opportunities for local people in connection with the operation of the pipeline, unless they chose to move to Fort Simpson, the nearest operation and maintenance headquarters.

It is not anticipated that there will be any direct contact between pipeline work crews and the settlement. Demand for skids, piles, etc. required in pipeline construction, and for rough lumber for construction work at Fort Simpson, could provide work for the local sawmill.

Highlights

The Prime Route of the pipeline does not pass near Jean Marie River and construction of the pipeline along this route would have no direct impact on the community. Some indirect effects could be experi-

enced through the employment of local labour and perhaps also through production of rough lumber by the community's portable sawmill.

5.14 NAHANNI BUTTE

Nahanni Butte is a small unorganized Native settlement located at the confluence of Liard and South Nahanni Rivers, about 90 miles from Fort Simpson. Its population was about 31 in 1971 (Community Data, NWT, 1972), and increased to about 75 in 1974 with a labour force of about 15 workers (Community Data, NWT, 1974).

Hunting, trapping and fishing continue to be the principal activities. Hunters and trappers make extensive use of the Liard River valley, the lower reaches of the South Nahanni River, and the northerly lowlands lying between the Franklin and Mackenzie Mountains. Big game is taken in the Mackenzie Mountains. Recently there has been some seasonal employment arising out of the development of the Pointed Mountain natural gas field and construction of the Mackenzie Highway.

Impact Assessment

The Applicant does not plan to build any facilities in the community or use any of its services.

Short-term unskilled employment opportunities may be available to settlement residents in a variety of activities associated with pipeline construction, for example, clearing the right-of-way, working in borrow pits, etc. It is unlikely that long-term employment will be available as operation and maintenance of the pipeline will be conducted out of Fort Simpson. Demand for forest products by the Applicant and by construction work at Fort Simpson could provide some logging work in the Liard Valley and residents of Nahanni Butte perhaps could participate.

The proposed pipeline route lies outside of trapping and hunting areas used by local residents.

Highlights

Nahanni Butte lies well off the pipeline route, and the only impact that the pipeline project may have in the community is some employment of local labour.

5.15 NORMAN WELLS

Norman Wells is a non-Native settlement at approximately River Mile Post 565 on the east bank of the Mackenzie River. It owes its location and existence to surrounding producing oil fields operated by Imperial Oil Limited. Population in 1971 was 300 (Lu and Mathurin, 1973) and in 1974 was 354 (Community Data, NWT, 1974).

Permanent full-time employment was available to 137 men and 30 women in 1974, with additional part-time work normally available to 11 persons (Francl and Associates, 1974a, Appx. B). During the same year there was a seasonal employment requirement of 123 persons, mainly in the summer. The permanent positions are manned by the resident labour force plus men who come to Norman Wells from southern Canada for varying periods of time. The small local Native labour force is mainly employed seasonally. Native people from nearby communities, particularly Fort Norman, also participate in the large amount of seasonal work.

The local economy and employment are based on the oil field and the refinery, fuel supply service, air and barge transportation, expediting and exploration work, and government and community services. Estimates of income are not available, but should be in the $7,000 to $12,000 range for resident workers. There is virtually no unemployment, and by the same token no social assistance.

Transporation services and facilities are adequate in terms of capacity and are of good standard. They include a wharf and barge service, a 6,000-ft paved airstrip and non-directional beacon, scheduled and charter air services, and winter road service. Community infrastructure is reasonably comprehensive and includes a piped water and sewer (utilidor) system, CN telecommunications, and a fire department.

Government and community services are somewhat more extensive than in other communities of the central Mackenzie. These services include a small hospital and nursing station, a school, welfare services, RCMP, a post office, a liquor store, a game management officer, a library, and community hall and skating rink. These services exist partly in relation to the needs of Norman Wells, but they are also related in part to the needs of other central Mackenzie communities, such as Fort Norman and Fort Franklin, which are serviced from this centre. Norman Wells has an elected settlement council.

Retail trade enterprises are minimal and the service sector is limited to a hotel, bar, restaurant, and bank. However, there are a variety of charter air services, surface transport companies and expediting contractors related to oil and mineral exploration.

Good terrain for expansion is not available around the present settlement without land-filling or developing a subdivision some distance away (Francl and Associates, 1974a). Present infrastructure has little capacity for expansion and any significant enlargement of the settlement would incur substantial costs.

There are perhaps five Native families who occasionally hunt and trap along the Mackenzie valley from Norman Wells and who range westward into the Mackenzie Mountains for big game. There is also some sports fishing and big-game hunting undertaken by non-Natives in the lakes and mountains to the west.

Impact Assessment

The right-of-way will be about 4 miles east of the settlement, and the access road from Norman Wells to the Mackenzie Highway, which will lie east of the pipeline at that point, would pass over the right-of-way. At Norman Wells the wharf at River Mile Post 565 is to be upgraded for the pipeline project. There will also be a materials stockpile, a communications tower, a block valve and helipad, and two borrow pits. The stockpile site will require 97,000 cu yd of aggregate. The operating and district headquarters to be located in the community will require an additional 78,000 cu yd.

Facilities site M-09 will be located about 22 miles upriver at Pipeline Mile Post 400 and will consist of a stockpile and compressor station; a construction camp; a communications tower and a helipad; two borrow pits from which 330,000 cu yd are required; and a temporary access road from the pits to the construction site. Apparently the 21 miles of pipe to be stockpiled at M-09 is to be hauled from the wharf at Norman Wells up the Mackenzie Highway during the summer of 1977. The airport at Norman Wells will service M-09 with respect to personnel and airborne supplies. The Mackenzie Highway also will be used for access to the facilities site.

Site M-08, located downstream of the community, will consist of a wharf, a permanent road, a materials stockpile and compressor station, a communications tower and helipad, and two borrow pits—630,000 cu yd of borrow material will be required for these facilities. Again, a permanent road will intersect the Mackenzie Highway. It is likely that traffic between Norman Wells and M-08 will consist largely of workers and air freight because of the

5,000-ft airstrip at Norman Wells.

There will be a considerable amount of unskilled short-term employment available in the vicinity of Norman Wells in connection with logistic activity, preparation of the right-of-way, preparation of camp and compressor sites, borrow pit and road building, etc. Logistic activity would begin in 1975 and the completion date for the compressor station for M-09 is slated for the end of 1980. However, most of the labour force of Norman Wells is permanently employed. The community probably would become a staging point for Native workers from communities such as Fort Franklin, and for imported southern workers. Thus there would appear to be a requirement for additional accommodation and food services.

As the community is to be an operating and maintenance District Headquarters, there will be up to 66 permanent jobs by the fifth year of pipeline operation. Again, this has implications on community growth, particularly housing, infrastructure, and local services. As with other Divisional or District Headquarters, the Applicant states a willingness to become involved with government and communities in order to provide a high standard of services and facilities to his operating and maintenance employees (Sect. 13.b.2.2).

Because the community is now oriented to the petroleum and transportation industry, and because of its strategic location with respect to pipeline construction and operation, there probably will be an influx of small contractors and other commercial and retail ventures to augment the present small service sector. The prospects for growth in this sector are bright in the short run, but resulting community requirements for serviced land, sewer and water, etc., will prove expensive (Francl and Associates, 1974a).

During the construction phase, major demands may be placed on such government services as medical and hospital services, law enforcement and possibly the administration of social assistance to transients who become stranded at the community. During the operations phase, some of these services will have to be augmented.

Highlights

Norman Wells lies close to the pipeline right-of-way and will be a major logistics and staging point. Moreover, it has been designated by the Applicant as one of his three northern operating and District Headquarters. It will, therefore, experience the impact of the pipeline with particular intensity. However, in many respects it is in an ideal position to absorb this impact, and perhaps to thrive and grow because of it: its population is largely non-Native and industrially oriented; incomes and standard of living are high; dependence on the traditional economy is virtually insignificant. Problems that may arise because of the pipeline would centre on questions such as the adequacy of the community's facilities and lands to cope with a rapid growth of activity, and the high financial outlays that may be required for community expansion.

5.16 OLD CROW

Old Crow is a Loucheux Indian village located on the north bank of Porcupine River just downstream from its junction with Old Crow River. It is the most northerly settlement in the Yukon Territory. There are no all-weather roads to the settlement; it is connected to the Dempster Highway by about 150 miles of winter road. It is readily accessible by air and is serviced from Whitehorse (500 air miles) and Inuvik (176 air miles); the settlement has a 5,000-ft gravel airstrip. Barge traffic comes from Dawson via the Yukon and Porcupine

Rivers.

The population in 1973 was estimated at about 200, which included a potential Native labour force of 51 men and 53 women. Native wage earners in 1973 consisted of 38 men and 19 women. Of the total community population, 17 persons were non-Native (Stager, 1974).

The bases of the local economy are government and community services, hunting, trapping and fishing, production of handicrafts, wood-cutting, and oil and gas exploration. Wage employment, which is the main source of earned income, is increasing in importance. Much of the wage work which currently is undertaken by local people is on a full-time basis. Seasonal wage employment opportunities also have increased during recent years (Stager, 1974). Hunting continues to be important and participation remains quite stable, but trapping is declining even though it is still important. The estimated per capita income from wage employment was $1,700 in 1973; while from trapping, the per capita income was $1,100. Income from all sources in 1973 would result in a "modal" family receiving approximately $6,800 (Stager, 1974). Income from trapping, wood-cutting, and handicrafts is variable from year to year and accounted for 15 per cent of total income in 1973. Although 66 per cent of wages earned by community residents derive from full-time jobs, there is some reliance on social assistance (Stager, 1974).

Community retail and commercial enterprises are limited but include: a cooperative store, a winter road, a post office, an airstrip, scheduled air services, and CN telecommunications. Government services consist of: a school, a nursing station, and RCMP. A doctor and a dentist visit occasionally from Inuvik. Community services and facilities include: two community halls, two churches, trucked water and garbage disposal, electricity, and a telephone system. There is a local Band Council.

The settlement is somewhat isolated geographically, but many Native residents have spent at least some time away from the community. Knowledge of the "outside" world is increasing, particularly among the young.

Due to the location of the airstrip and its safety zones, no further expansion can take place along the river bank at either end of the village; there is limited space for additional construction on the present site. Use of land for hunting, trapping and fishing covers in excess of 1,500 sq mi and includes the Old Crow flats, about 50 miles north of the Porcupine River (Stager, 1974).

Impact Assessment

The Coastal Route, which is the Applicant's preferred route, would be about 100 miles from the settlement, and therefore would have little direct impact on the community. Construction along this route perhaps would lead to some employment of local labour but this would be entirely at the discretion of community residents. Construction of the Interior Route alternative would have a much more major impact on the community. This is discussed in the chapter dealing with alternative routes.

Highlights

If the pipeline linking the Alaskan North Slope and the Prime Route in the Mackenzie Valley is constructed along the Coastal Route there will be no impact on Old Crow with the possible exception of some local employment.

5.17 TROUT LAKE

Trout Lake is a small unorganized Indian settlement situated on Trout Lake at the mouth of the Island River. It is about 105 air miles south of Fort Simpson. In 1974 the population numbered about 60 people. The labour force, consisting of about 20 people in 1974 (Community Data, NWT, 1974) is seasonally active at hunting, trapping and fishing. Local residents also operate a sports fishing lodge during the summer. A few people occasionally leave the community to take wage employment elsewhere, mainly in construction.

Annual average income per family is in the $2,000 to $3,000 range. The residents are self-reliant, and there appears to be little social assistance.

Contact with the community is maintained by float plane in summer, and winter road and ski-equipped plane in winter. Community and government institutions and services are minimal, consisting of little more than a Band Council, a school, and a church.

Use of the surrounding land for hunting, trapping and fishing is extensive. Prime areas include Trout Lake, and the watersheds of the streams that empty into the lake and also the Trainor Lake area to the east.

Impact Assessment

The right-of-way and construction activity centred at site M-17 will be about 25 miles east of Trout Lake. Currently there is no established winter road or water access between the community and this area. However, the Applicant proposes to build a 2,400-ft airstrip at M-17, and this could be of some future interest to the community. The right-of-way skirts the eastern shore of Trainor Lake, where people from Trout Lake hunt, trap and fish. Care would have to be taken to avoid damaging interactions between the local use of this area and the pipeline.

If they choose to do so, residents of Trout Lake could take short-term employment with the pipeline during the winter seasons of 1976-77 and 1977-78. The Applicant does not propose to build or use any facilities in the community. There should be virtually no contact between local residents and pipeline workers nor will the pipeline create any permanent jobs in the community.

Highlights

Trout Lake is a small community located well off the pipeline route. Apart from some local residents being employed on the pipeline during construction, there likely will be no interaction between the pipeline project and the community.

5.18 TUKTOYAKTUK

Tuktoyaktuk is a hamlet located on tidewater north of the entrance of the eastern channel of the Mackenzie River into Kugmallit Bay on the Beaufort Sea. Its population in 1971 was 605 (Lu and Mathurin, 1973), and in 1973 the population was estimated at 645, of which 578 were Eskimos (Gemini North, 1974, Vol.2, p.208, Ch. IV). The community is 77 air miles from Inuvik; a winter road is operated intermittently to points to the South. Tuktoyaktuk is the proposed northern terminus of the Mackenzie Highway.

The Native labour force in 1969-70 was estimated at 114, consisting of 91 men and 23 women (MPS, Vol. 6). At present, the total Native labour force may number around 130 (100 men and 30 women), although this is perhaps conservative. The average earned income of Native workers in 1969-70 was about $2,000 per year. However, with considerable

recent exposure to oil development, family income may be approaching levels comparable to Inuvik. A reasonable estimate would place income from wage employment in the $4,500 to $7,000 range.

Employment is based mainly on petroleum exploration and associated developments such as construction and transportation. Many individual jobs are of short duration, but the number of activities (e.g. seismic survey, drilling, island building, stockpiling, etc.) results in almost continuous year-round demand for local labour. In addition, the Native people continue seasonal trapping, fishing and hunting, taking both land and marine mammals. Employment in government and community services is relatively minor.

Commercial and retail enterprises and facilities include a general store and fur trader, regular air service, a harbour and barge service, 3,500-ft MOT airstrip, CN telecommunications, television, a local transport contractor and expeditor, a winter road to Inuvik, fur garment manufacture, a restaurant, and fly-in banking services from Inuvik. Community services include trucked water and garbage disposal, churches, a community hall, a fire department, and curling rink. Government services include a nursing station, schools, RCMP, a travelling welfare service from Inuvik, a post office, electricity, and a library. There is an elected hamlet Council.

Tuktoyaktuk has played an important trans-shipment role in the transport system which Northern Transportation Company Ltd. operated in the western Arctic. At the nearby wharf, goods are loaded from Mackenzie River barges to coastal vessels or sea barges which supply communities and DEW line stations extending from Spence Bay in the east to the Alaskan North Slope in the west.

With the acceleration of petroleum exploration in the Beaufort Sea, the community recently has experienced sudden and intensive economic and social change. Further physical growth is possible, although facilities such as water supply, sewer service, electricity, and roads would require refurbishing if they were to be adequate for a modern community.

Impact Assessment

The hamlet will be some distance from the proposed pipeline. Unless natural gas gathering systems and processing plants are developed in the immediate area, little impact should be directly attributable to the pipeline. However, petroleum exploration activity has had considerable impact on this community since 1969, and this will likely continue.

The local labour force has had a considerable involvement in petroleum exploration and development. This experience undoubtedly would be transferable to other industrial situations and local workers probably could obtain employment in pipeline construction if they wanted to. The local handicrafts industry should experience increased demand because of the high-income transients from the South working on the pipeline. However, retailing of local products likely would occur at Inuvik.

The pipeline route on Richards Island and the Parsons Lake lateral cross areas used by the people of Tuktoyaktuk for traditional pursuits. It is possible that the pipeline may have some negative impact on these pursuits.

Highlights

Tuktoyaktuk lies well off the pipeline right-of-way and will not be directly affected by the construction of the pipeline, although some negative

impacts may be experienced from the development of gas-gathering systems. The community already has had considerable experience of rapid change in its role as one of the main logistic support centres for petroleum exploration in the Beaufort Sea and nearby mainland areas. As a result, the local labour force - insofar as it is not already fully employed - should be able to adapt to jobs in pipeline construction and gas field development relatively easily and quickly.

5.19 WRIGLEY

Wrigley is a Native settlement located on the east bank of the Mackenzie River, approximately half way between Fort Simpson and Norman Wells. The population was 155 in 1971 (Lu and Mathurin, 1973) and about 175 in 1973 (Settlement Secretary, pers. comm., 1974). Its labour force in 1969-70 was estimated as 34 persons (MPS, Vol. 6), and reported by the community as being 62 in 1973 (Settlement Secretary, pers. comm., 1974). This figure consisted of 48 men and 14 women in 1973 and may be somewhat high; it may include people who are now working in larger communities, but are still considered "Wrigley" people.

The settlement continues to depend heavily on hunting, trapping and fishing for cash income and food. Wage employment in seasonal activities such as Mackenzie Highway clearing and local construction, as well as in community and government services, is of secondary importance. Average annual individual income from hunting/trapping and wage employment in 1969-70 was about $1,500 (MPS, Vol. 6). Current Native family incomes may be in the $2,500 to $4,000 range. There is considerable seasonal unemployment. Social assistance caseloads and the payments of assistance for economic reasons have increased in the welfare district which includes Wrigley (Gemini North, 1974, Vol. 2, Tables 7.15 and 7.13).

Government and community services and facilities are minimal and include a nursing station, a school, a post office, a small airstrip, electricity, a wharf and barge service, a winter road, CN telecommunications, trucked water and garbage disposal, a fire department (volunteer), a library, and a community hall and skating rink. Commercial establishments consist of a Hudson's Bay Company store, a fur trader, a coffee shop, and a community sawmill. There are elected settlement and Band Councils.

The people of Wrigley trap, hunt and fish both northward and southward along the Mackenzie Valley. They range eastward up the Willow Lake River and the River Between Two Mountains, and westward into the Mackenzie Mountains in search of big game.

Impact Assessment

Wrigley is midway between two construction camp/compressor sites, neither of which will have an airstrip. The Applicant indicates the Wrigley strip, which is contiguous to the settlement, will be upgraded, presumably to meet the requirements of the two sites (Sect. 13.a.3.2).

At its closest, the settlement is approximately three miles from the right-of-way, and there will be a helipad and block valve near to this point. These facilities will not be connected by road to the Mackenzie Highway.

However, there would be access to the right-of-way via a road from the Mackenzie Highway at site M-12 near Pipeline Mile Post 534, and upstream near Pipeline Mile Post 570, where the Mackenzie Highway will actually cross the right-of-way.

Associated with site M-12 will be a wharf (River Mile Post 384) and a borrow pit, with 4 miles of connecting permanent road to M-12. At M-12 itself,

there will be a construction camp, a compressor station, a materials stockpile, a communications tower, and a borrow pit. Borrow material requirements associated with M-12, including its wharf and road, will be 665,000 cu yd. The communications tower and helipad, which will be located at about Pipeline Mile Post 550, will require 2,000 cu yd of borrow material, but the Applicant has not indicated the source of this.

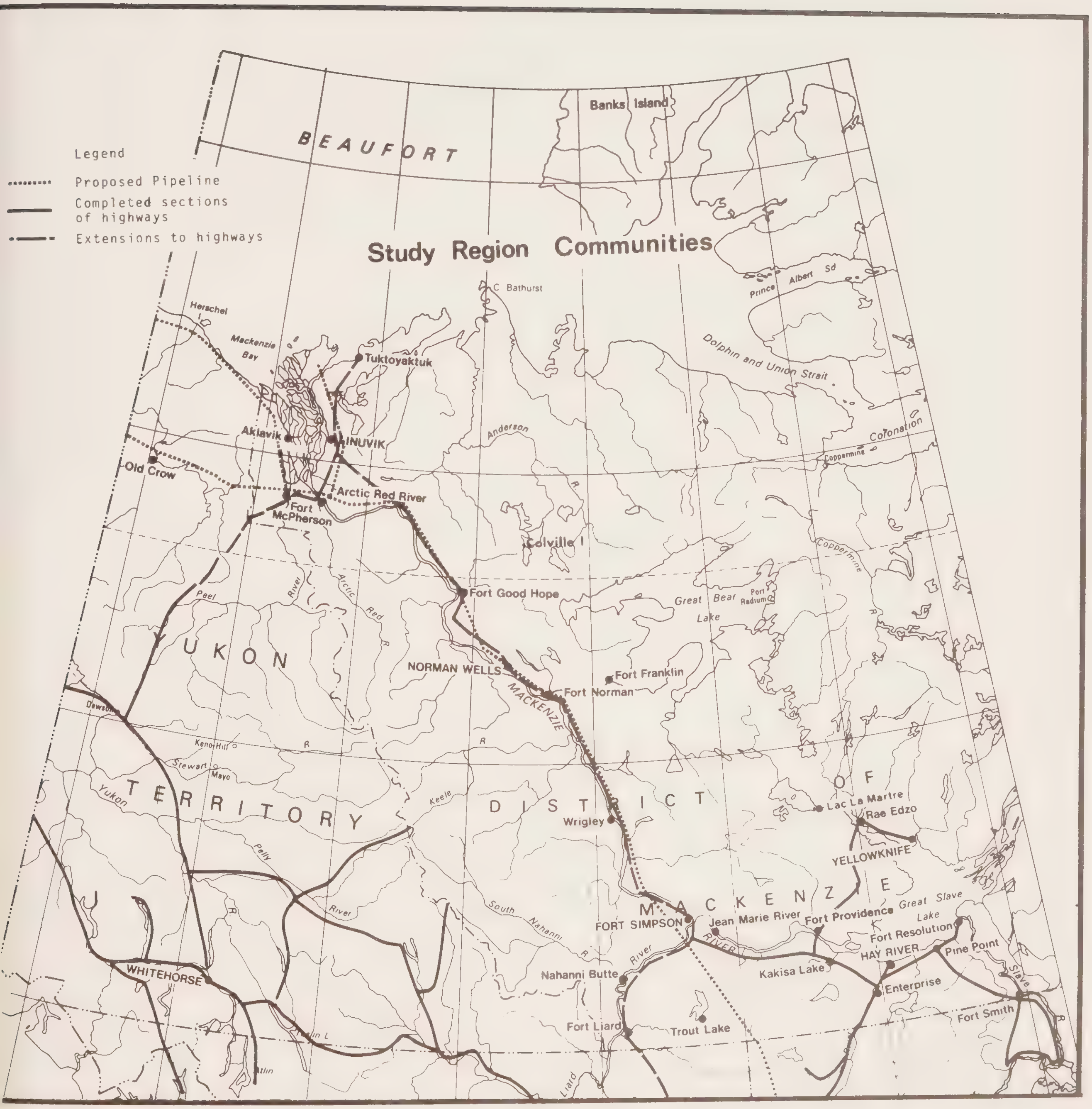
Associated with site M-13 will be a wharf (at River Mile Post 334) and a permanent road from the wharf along the River Between Two Mountains to the construction camp, which will be the location of a compressor station, a materials stockpile, a communications tower, and a helipad. The road will cross the Mackenzie Highway. Two borrow pits also will be associated with M-13, the favoured pit being northeast across the River Between Two Mountains, while the other appears to lie about 4 miles upstream. Total borrow material requirements for the wharf, the road, and facilities associated with M-13 will be 565,000 cu yd of aggregate. While the assembly of this material will largely use the Applicant's permanent roads, a short part of the trip will be along the Mackenzie Highway, including the bridge over the River Between Two Mountains.

Seasonal employment would be available for five years as logistic activity is slated to begin early in 1975, with site preparation of M-13 scheduled for late 1975, and actual compressor station construction to be completed by the end of 1980. The schedule for work at M-12 falls in the period from early 1976 to mid-1979. The demand for skids and other local forest products could provide some employment for the community sawmill. There should be substanial demand for short-term unskilled labour for many activities related directly and less directly to the pipeline, apart from mainline construction. However, during the operations phase, the compressor stations, communications towers, and block valves will be attended and maintained out of the regional maintenance centre at Norman Wells. It is unlikely, therefore, that Wrigley residents will find long-term employment with the pipeline unless they are willing to leave the community.

Aside from upgrading the airstrip, the Applicant's plans do not indicate the modification or expansion of any other facilities at the settlement. Thus, the impact on the settlement infrastructure should be minimal. However, because of the airstrip and connections by bus and truck to M-12 and M-13, there may be considerable interaction between pipeline workers and local residents.

Highlights

The proposed pipeline will pass quite close to Wrigley and the impact on the community therefore will be complex and of considerable magnitude. Not only will local people be employed in pipeline construction, but it is also probable that there will be direct interaction between pipeline workers and the community, and perhaps some interference with local hunting, trapping and fishing. Community facilities, such as the airstrip, will be upgraded and used for pipeline purposes. Care will have to be taken to ensure that any disturbances that occur during pipeline construction do not permanently impair the ability of this small community to function.



Study Region Communities
Legend
Proposed Pipeline
Completed sections of highways
Extensions to highways
BEAUFORT
Banks Island
Prince Albert Sd
C. Bathurst
Dolphin and Union Strait
Coronation
Coppermine
Herschel
Mackenzie Bay
Tuktoyaktuk
Aklavik
INUVIK
Anderson
Old Crow
Arctic Red River
Fort McPherson
Colville l
Fort Good Hope
Great Bear Lake
Port Radium
Peel
Arctic Red
YUKON
NORMAN WELLS
Fort Norman
Fort Franklin
MACKENZIE
Dawson
Keno Hill
Stewart
Mayo
TERRITORY
Yukon
Keele
DISTRICT OF MACKENZIE
Wrigley
Lac La Martre
Rae Edzo
YELLOWKNIFE
Pelly
River
South Nahanni R
FORT SIMPSON
Jean Marie River
Fort Providence
Great Slave Lake
Fort Resolution
HAY RIVER
Pine Point
Kakisa Lake
Enterprise
Nahanni Butte
Fort Liard
Trout Lake
Fort Smith
Slave R
WHITEHORSE
Atlin
Liard

ENVIRONMENTAL ASSESSMENT

CHAPTER 6

NATURE OF ENVIRONMENTAL REVIEW

6.1 Review Tasks, Expanded Guidelines and Index

There were two main review tasks for the Assessment Group to accomplish. The first was to examine the material formally submitted by the Applicant to see how completely it included the environmental aspects specified in the "Expanded Guidelines for Northern Pipelines" as being of concern to government. The criterion was essentially quantitative and the two questions posed by the Assessment Group were: "Has the Applicant provided information on such-and-such an environmental aspect?" and "If the Applicant has provided information on such-and-such an environmental aspect, is the answer adequate for the Assessment Group to conduct its review and for full understanding of the specific environmental concerns at formal hearings?" No part of this first task involved a judgment of the Application. In contrast, the second task, which has resulted in this review report, has constituted an appraisal or judgment of the quality of the materials, answers, and proposals submitted by the Applicant.

Before it is explained how each of these two main tasks was carried out, a few remarks will be made on two other, smaller tasks that were performed beforehand. These arose partly from the nature of the Expanded Guidelines and partly from the nature of the Application.

Regarding the Expanded Guidelines, two points were taken into account. The first was that as the Guidelines cover both oil and natural-gas pipelines, some of the environmental concerns or aspects included in them had to be adjusted in emphasis for appraisal of an Application for a chilled natural-gas pipeline rather than a heated oil pipeline. The reason for this, of course, is that a chilled natural-gas pipeline poses appreciably less environmental hazard in the operational stage than a heated oil pipeline. The second point concerns the comprehensiveness of the Guidelines, and it is worth making because much energy can be misapplied analyzing the finer points of adequacy of guidelines. In preparing guidelines such as these, two contrasting approaches could be followed, one favouring a few broad principles and the other endeavouring to list everything. The environmental parts of the Expanded Guidelines come somewhere between these two extreme positions, and the important point is that they are not intended to be fully comprehensive. They are: "...intended to indicate to potential applicants some of the major topics that should be included in such an environmental assessment." In a sense, then, they convey the general principles of sound pipeline development, and do not detail the very many specific environmental concerns that would appear in a comprehensive list. The Assessment Group has assumed the Applicant has correctly interpreted the nature and intent of the Expanded Guidelines and the Group has appraised the Applicant's submission in the same light. In other words, absence of reference to a specific relevant concern in the Expanded Guidelines does not constitute a reason for its

omission in the Application or in the review.

The other preliminary task arose from the voluminous nature of the environmental part of the Application. As Chapter 1.2 above makes clear there are numerous items including volumes, maps, diagrams, photomosaics, etc., arranged in such a way that often the same subject material appears in different places discussed in different ways. There was no index, but it seemed essential to have one, both to aid the two review tasks of the Assessment Group and possibly to assist in the formal hearings of the Inquiry. A 235-page index was prepared, largely by one member of the Assessment Group. It is entitled "An Index to the Application of Canadian Arctic Gas Pipeline Limited with Particular Reference to Environmental and Technical Topics". The Index covers eight main Sections of the Application - 8a, 8b, 9, 13a, 13b, 14d.N, 14d.S, and 14e.

6.2 Requests for Supplementary Information

The purpose of the first task of the Assessment Group has been explained in Chapter 6.1 above; viz., using the Expanded Guidelines as a reference document, to prepare a report on aspects of the Applicant's submitted material that are considered to lack information required for review.

After the Application had been received during April 1974 by the Assessment Group, it was realized that the above task was not as straightforward as had been imagined, because of the nature of the Application as discussed in Chapter 1.2 above. An engineering development can be viewed as involving five main phases: (i) feasibility and design concepts; (ii) final design; (iii) contract specifications; (iv) contract performance; and (v) monitoring of construction and operation.

The present Application falls somewhere between phases (i) and (ii). Final design is not present; hence, many of the details required for full assessment are not present, and their absence greatly influenced the approach taken by the Assessment Group in formulating questions. In a nutshell, it would have been unhelpful to all if attention had been focused on specific detailed points that are not covered. Rather, the approach used each guideline to seek out the principles and rationale underlying the specific proposals, especially by requesting examples for a few typical sites, situations or conditions. It was recognized that it is impossible to know numerous details before the final design stage, but it was hoped that by asking appropriate questions on principles and rationale - backed up by requests for examples - a constructive review of the Applicant's proposals would be possible and that the chances of important aspects not coming to light would be minimized.

A copy of the "Requests for Supplementary Information" is appended to the published version of this report.

6.3 The Main Review or Assessment

Some General Constraints

The purpose of this section is to explain the nature of the main environmental review task and to provide the rationale for the form taken by the environmental review report.

To avoid confusion in terminology it may be explained at the outset that the Main Environmental Review or Assessment, which is elaborated in Chapters 8 and 9 and parts of 10 and 11, is essentially a review of the Applicant's proposals. In the review process, the Assessment Group has used the Expanded Guidelines as a check-list or reference document of environmental concerns, but a variety of other documents have been used as

sources of environmental knowledge as explained in Chapter 1.1 above. The Application, with its supporting exhibits containing the Applicant's proposals relating to engineering, construction, operation, environmental interactions, etc., falls within a class of document that is often referred to these days as an Environmental Impact Assessment. But although the Assessment Group has been preparing a so-called Assessment Report, it has not, unlike the Applicant been conducting or supporting research studies eliciting new information on environmental interactions. It has not, therefore, carried out an Environmental Impact Assessment in the normally understood sense of this term and it has not conducted *de novo* studies on environmental interactions. On the other hand, in reviewing the Applicant's interpretations of environmental interactions and his translation of them into specific engineering proposals, the Assessment Group has performed a somewhat parallel analytical process.

Having established the review nature of the present Assessment, it is necessary next to remark on two terms-of-reference that put the Assessment and the task of the Assessment Group somewhat outside normal review requirements. First, the Assessment was to contain no conclusions or recommendations as such. Rather it was to summarize the analysis of interactions or cause/effect relationships in a way suitable for others to re-cast and apply.

A second feature of the review task which considerably increased the difficulty of the job, arose from the Application not being final design but rather somewhere between the feasibility/design concept stage and final design. In effect, it was difficult to apply two of the normal tests of conventional reviewing: (i) appraisal of the actions proposed and (ii) appraisal of the basic data and methodology upon which the proposals are based. The reason for this, of course, is that comprehensive base data are largely absent from a feasibility stage that concentrates on principles, theory and assurances. The "Requests for Supplementary Information" were often attempts to elicit the data necessary to bring the debate down from the theoretical to the practical. In the absence of many base data (and particularly because the assessment report has been prepared without benefit of the Applicant's "Responses"), the Review proceeded on the assumption that many of the Applicant's assurances on actions would, in fact, be implemented.

The Form of the Review

Perhaps the most difficult task was deciding on the form the Review should take. If it can be justly claimed that the science of Impact Assessments is in its infancy, then that of reviewing them must be embryonic. The difficulties arise in several ways. First, there are those outlined above stemming from the special requirements of the Review and the special nature of the Application. Then there are those that stem from the size of the development project, its many component activities, and the great geographical distance and diversity of the area traversed.

The short history of Environmental Impact Assessments and their review in general, has not been a happy one, and there has been the serious risk that all concerned become drowned in paper. A paramount need, especially where there are limitations in the time available, seems to be to strike a balance between the essential and the exhaustive. A review must be authoritative, incisive and comprehensive in the sense of including the important, but it defeats its own ends if it becomes unreadable and indigestible by excessive coverage of minor concerns. But how is such a Review to be organized? Should it follow the arrangement of the Application, that of the Expanded Guidelines, or that of the

Environmental-Social Program's Report to the Task Force on Northern Oil Development (1974)? Should it take the entire 1,200-mile Prime Route as a whole, or split it into some five to 10 geographical areas, or go down to a mile-by-mile discussion? Should it take the innumerable impacting actions of the Applicant as the prime focus of attention and orient the Review around the effects each of these impacting actions might have on a host of environmental components? Or should the Review be oriented the reverse way, with a consideration of how each environmental or impacted component might be affected by various pipeline activities? Should the construction stage be separated completely from the operation stage, for example, or should activities common to both, such as aircraft, be selected for attention, regardless of stage?

From a study of several completed reviews, all appeared to have involved preparation of a matrix or grid, with the impacting or project variables marked off along one axis and the impacted or environmental variables marked off along the other. Unlike several proposed methodologies for the preparation of Environmental Impact Assessment Statements, however, most of these reviews did not quantify to any extent the interactions established by intersections in the matrix. At most, they grouped the interactions into not more than three levels - high, medium and low, and the whole purpose of the matrix seemed to be more of a useful check-list to ensure no important interaction was omitted, rather than the basis of some useful mathematical quantification that would reveal a gradation of importance to the interactions.

An analysis of the environmental part of the Expanded Guidelines showed that most concerns were centred on environmental components. Several, however, were centred on pipeline components and some, again, were more complex, revealing sequential concerns of pipeline-on-environment-on-pipeline. This brings out an intrinsic limitation of the two-dimensional matrix, which cannot portray the more complex sequential interactions that take place both in natural ecosystems and in ecosystems modified by man. In effect, therefore, the matrix was used, in the reviews, in a check-list way and in assisting to identify interactions of importance, but the selection of topics to review seemed to arise more in a subjective than analytical way. The particular choices of topics were not necessarily project- or environment-oriented, but were certainly selected on the basis of considerable intuitive knowledge of processes and components of the environment.

This approach was adopted by the Assessment Group for its Review but before the selection of the specific matrix and topics is discussed, it is necessary to comment on geographical approaches, for the proposal very much concerns location and its suitability. The mile-by-mile approach was rejected because of the preliminary nature of the Applicant's plans. The five- to 10-geographical region approach appeared initially to have merit, but it was not adopted because the boundaries of such regions have significance for some environmental components and not for others. One or two regions have discrete significance in important ways, but the delineation of the others would divide environmental components rather than give them entity. This is not to say, however, that geographical location has been ignored, for within the treatment of the topics selected, particular attention has been focused on identifying locations where environmental concerns manifest themselves.

The Specific Matrix and Selected Topics

In preparing the environmental matrix, impacting or impacted variables judged to be significant were first identified. Thus for the Pipeline

there were six main stages—preconstruction, construction, start up, operation, maintenance, and abandonment. Within each of these there were numerous activities, such as waste disposal, access roads, trenching, air traffic, and river crossings. Altogether, in fact, there were 141 such activities.

Similarly, for the environmental components there were 19 larger categories - topography, climate, soil factors, bedrock factors, mineral resources, geomorphic processes, water quality, water quantity, river channels, minor drainage patterns, permafrost, icings, mammals, furbearers, other upland furbearers, birds, aquatic habitat, fish and vegetation. These were sub-divided to make a total of 136 environmental components. Next, the interactions between the pipeline and environmental variables were rated as being of major, medium or minor potential significance or of no significance.

The result was 19,176 possible interactions between the 141 pipeline activities and the 136 environmental components. Of these 2,362 fall within the category of having major potential significance, 1,553 are medium and 1,311 minor. Therefore, nearly 73 per cent of possible interactions between the pipeline activities and the environment were assigned no significance, while nearly 12 per cent have major potential significance. Of course all these interactions could not be highlighted in the review but, nonetheless, the exercise of identifying them did lay the foundation for the identification of a number of major topics of concern which form the substance of Chapters 8 and 9, and part of 10 and 11.

A few further points may be made regarding the topics. First, they are not all the aspects by any means that could be selected for examination, but the Assessment Group considers that they cover those matters where major environmental concerns could directly or indirectly arise.

Second, topic selection avoided the constraint of having to adopt either a project-oriented or environment-oriented approach. Individual topics embody either or both orientations. Many in fact do so, such as fire, which may originate within the pipeline system and damage the environment or may originate elsewhere and affect the pipeline in such a way that a new environmental threat arises.

A third feature is that each topic write-up endeavours to be a complete account in itself, with limited need for cross-reference to other topic reports. This may make for some overlap, but where an aspect is developed more fully elsewhere, a cross-reference is provided.

Finally, the nature of the individual topic reports militates against the production of an overall summary, and no such summary has been prepared for this Review.

The Structure and Preparation of the Topic Reports

Topic reports conform to a standard format containing sections entitled: Introduction, Applicant's Data (sometimes Applicant's Proposals or Applicant's and Other Data), Concerns, Highlights and Literature Sources (sometimes Bibliography).

The Introduction gives a simple overview, and provides information on the scale or seriousness of the concern and what the Applicant does or does not propose to minimize or avoid harmful impact. Any "Request for Supplementary Information" pertinent to the topic is mentioned, and commonly the Assessment Group's summarized thoughts on the concern are also recorded. The *Applicant's Data* section explains what the Applicant proposes and what background data support such proposals. For some topics, specialized background biological data are included. The *Concerns* section constitutes a

critique of the Applicant's proposals and may include remarks on the ways in which the Assessment Group considers harmful impact can be avoided and on gaps in knowledge that might be remedied by the final design stage. The *Highlights* bring together the more important ideas from the Concerns section and present them in point form.

In preparing and writing the topic reports, the environmental members of the Assessment Group formed multi-disciplinary teams of different composition for each topic. In effect, each specialist had the lead responsibility for generating some five to 10 topic reports and was assisted by some two to five collaborating specialists, either from the Assessment Group or from other authorities. The following questions were assembled by the group to provide some uniformity in approach to the various topics.

Questions relating to the Applicant's background studies:

(a) are the subjects relevant?

(b) are the materials and methods used appropriate?

(c) have sufficient experiments been performed?

(d) are the conclusions a valid interpretation of the experimental results?

(e) are the conclusions adequate as a basis for design?

(f) should additional or other results be obtained to strengthen the basis of the design principles?

(g) would quite different background studies have been more appropriate?

Questions relating to the Applicant's use of existing knowledge:

(a) are the proposed actions based upon the best available knowledge?

(b) if the best available knowledge has not been utilized, would it have been straightforward to obtain it?

(c) is the best available knowledge rudimentary or sophisticated?

(d) if the best available knowledge is rudimentary, has this been adequate or inadequate for a soundly-based project proposal?

(e) if the best available knowledge is inadequate would it have been simple or difficult to sponsor studies to improve it?

(f) are there studies that should be implemented that are necessary for environmentally effective design of the natural-gas pipeline?

Questions relating to impacts of Applicant's proposed actions:

(a) are the impacts temporary, permanent...?

(b) are they instantaneous, progressive, cumulative, synergistic, individual, sum of individual, sequential, delayed, primary, secondary, summer, winter, reversible, irreversible, adverse, beneficial, catalytic...?

(c) are effects large, small, avoidable, unavoidable, low intensity, high intensity...?

(d) are effects easy to clean up, difficult to clean up...?

(e) has the Applicant reasonably accurately assessed the effects of his activities on environmental components?

(f) are the effects harmful, beneficial?

(g) if the answer to (e) is no, how serious is the error?

(h) if the effects of certain proposed actions are important and harmful, can the actions be modified to make them less harmful or acceptable?

(i) if the effects of certain actions are important and harmful, and the actions cannot be modified to make them less so, are alternative actions of a less harmful nature available?

Questions relating to the Applicant's concepts and procedures:

(a) are the concepts and procedures adopted by the Applicant those most likely to minimize the destruction, degradation, alienation and misuse of the environment and its components?

(b) are the concepts and procedures adopted by the Applicant those most likely to avoid environmental hazards to the pipeline and its associated facilities, which, in turn, could lead to adverse effects on the environment and its components?

(c) are the concepts and procedures adopted by the Applicant any less adequate for the long-continued stage of pipeline operation than they might be for the more immediately obvious construction stage?

(d) how effective are the Applicant's procedures for warning of or detecting the development of conditions likely to lead to the degradation or harm of environmental components?

(e) how effective are the Applicant's procedures for dealing promptly with emergencies?

(f) how effective are the Applicant's proposals for rehabilitating environmental components following construction, repairs and other damaging activities?

(g) how effective are the Applicant's proposals for controlling contractors and field crews so that design principles and specifications are carried out as intended and the unplanned use, alienation, degradation and destruction of environmental components is avoided?

CHAPTER 7

OVERVIEW OF PIPELINE DEVELOPMENT

Introduction

This section provides a brief chronological overview of pipeline activities and the environmental concerns arising from them. It is intended as a framework to place in context the selected environmental issues that are developed in greater detail in the subsequent parts of this report. Despite the lack of detail in the presentation, it illustrates the recurrence and repetition of various environmental interactions and concerns through the sequence of activities involved in pre-construction, construction, operation, maintenance and abandonment of the pipeline. In this overview, it is assumed that the pipeline right-of-way and all other lands to be used by the pipeline will be selected only after due allowance has been made to avoid land-use conflict, where the pipeline lands overlap on areas such as the following:

- fishing, hunting, trapping and camping areas used by native people;
- burial or archaeological sites;
- established or potential land reserves;
- areas with unique landscape features or particular aesthetic qualities;
- recreation or developmental areas (both present and future);
- areas containing scarce resources (timber, water supplies, gravel, etc.) presently or potentially required for local use; and
- critical habitat for mammals, birds, or fish.

In the overview that follows, no further reference is made to these locational questions. Moreover, it is assumed throughout that there is adequate engineering and environmental inspection during all phases of the project, that monitoring and surveillance systems provide early warning of impending hazards, that workers are adequately trained to recognize and make due allowance for environmental concerns, and that planned schedules (time of year) are adhered to.

Control and Location Surveys

The first on-the-ground pipeline activities, following final choice of location and land requirements, and completion of design, will be control and location surveys. These operations will be carried out by small work crews using helicopters, light vehicles and bulldozers, and will take place well in advance of the main clearing and construction. In the *control surveys*, which will be a summer-time activity, access to instrument points miles apart will be by helicopter. Helicopter pads will have to be cleared in forested areas but other ground disturbance will be limited. The *location surveys* require a line of sight along the right-of-way, along all access roads and around all areas of land to be used by the pipeline project. In forested areas a cut line 8 to 12 feet wide will be cleared by bulldozer

along all survey lines, generally during winter. Disposal of brush is proposed to be done some time after the line clearing, during the construction phase of the project. In areas of sparse tree cover, where the surveying can be done without extensive line cutting, the job will normally be done in summer when transportation is by helicopter and whatever clearing is required will be done by hand. Survey crews will be "accompanied by one or more inspectors whose qualifications and duties will relate to protection of environmental, archaeological and, where relevant, human socio-economic values" (Sect. 13.a.6.2). The activities most likely to bring about environmental effects are those involved in bulldozer clearing of survey lines in forested areas, particularly areas with high ice-content permafrost, and include the line-clearing process itself; the movement of vehicles and camps along the line; clearing of approaches to rivers a substantial time in advance of implementation of slope and erosion controls, and construction and removal of temporary stream crossing structures.

The principal environmental interactions or concerns which potentially could arise from survey activities relate to permafrost degradation, slope stability and erosion, fire hazard, and effects of siltation of waterbodies on fish and other aquatic organisms.

Test drilling may accompany or follow the location surveys, although this matter is not considered in the exhibits supporting the Application. It will involve movement of drilling vehicles, personnel vehicles and temporary camps along some of the survey lines, and bulldozing of additional lines. Assuming these activities will take place in winter, their potential environmental effects will be similar to those connected with bulldozer clearing of survey lines in forested areas.

Pre-Construction Activities

Extensive work is done on the ground before the actual ditching and laying of the pipe can begin. During the summer, 1½ years before pipe laying, construction of wharves and stockpiles is commenced and equipment is placed at these sites in preparation for the tasks to be done during the winter. In this first winter, the wharves, stockpile sites, airfields, permanent roads and camp/compressor sites are built using gravel and other material from major borrow pits. During the same period, trees are cleared from the pipeline right-of-way. Then in the following summer, construction of camps and associated facilities is completed concrete weights are cast for future use in control of pipe buoyancy, and a major mobilization of supplies and equipment is undertaken in preparation for pipeline construction.

Establishment of Wharves and Initial Stockpiles

During early summer, the trucks, bulldozers, cranes, camps and fuel will be placed at the wharf-stockpile sites to prepare these sites for equipment and supplies that will arrive later in the same summer. At some wharf-stockpile sites, this initial equipment could be sent in via the Mackenzie Highway, or from communities or other existing facilities, but in many places it will be necessary to establish a bridgehead at a previously undeveloped wharf site. Presumably the initial development in such areas would involve clearing, levelling and drainage of the land adjoining the wharf area, setting up fuel storage tanks and small camps, and preparing the water frontage to facilitate unloading of equipment from barges. It is assumed that little or no borrow material could be obtained to build up and grade these sites during the first summer except at sites in communities or adjacent to the Mackenzie Highway. Late in the same summer,

he fuel, camp and equipment needed for the following winter's work will be barged to the wharves nd transferred to the stockpile sites.

he principal environmental interactions or conerns that could arise from summer activities t wharves and stockpile sites relate to terrain nd aesthetic disturbance, siltation of waterodies, spillage of fuels, disturbance of fish nd other aquatic organisms, destruction of critical terrestrial habitat, disturbance of mammals r birds by noise, and archaeological salvage.

Building of Facilities Sites and Permanent Roads

n the autumn following the above activities, as oon as frost permits, winter or snow roads are uilt from the wharf and stockpile sites to the orrow-pit areas, airfields, and camp/compressor ites. Trees are cleared from the above sites as ell as from future permanent roads and from any ncleared portions of wharf and stockpile sites. hen gravel and other materials are excavated from he borrow pits and are dumped and graded to build p the roads, airfields, camp sites, wharves and tockpile sites. As construction of these "fills" ears completion, culverts, ditches, and other rainage and erosion-control structures will be uilt. In the early winter, work camps for temorary or longer term use will be moved into the arious work areas from the wharf-stockpile sites s soon as road conditions permit, appropriate ater and sewage systems and fuel storage facilities for camps, vehicles and aircraft will be nstalled. As soon as granular pads can be built p, the first stages of the main construction amps at the future compressor sites will also be uilt.

he principal environmental interactions or conerns that could potentially arise from these winter activities relate to terrain disturbance, permafrost degradation at borrow sites and all cleared and filled areas, damming or channelling of drainage in all the same areas, siltation of waterbodies, sources of water for ice roads, disturbance of fish and other aquatic organisms, destruction of critical terrestrial habitat, disturbance of mammals or birds by noise, timing of commencement of work relative to freeze-up and timing of borrow and fill activities relative to sensitive periods for fish or wildlife, sanitary arrangements at camps, visual aesthetic disturbance, archaeological salvage, and prudent use of merchantable timber and granular resources.

In some segments of the pipeline route in the northern territories, the above activities are scheduled to take place during summer rather than winter. In this period, concerns about disturbance of birds and mammals by construction noise or machinery would be different from, and commonly greater than, those resulting from winter operations. Of course, the potential for ground disturbance in sensitive permafrost areas (with attendant engineering and environmental problems) is greater during the summer than during winter, leading to substantial concerns over vehicle and machinery movements involved in borrow and fill operations. Fish migration and spawning during summer and autumn coupled with the high potential for siltation of watercourses from borrow and fill operations lead to particular concerns over disturbance of aquatic ecology.

Right-of-way Clearing

Trees and brush will be removed from the pipeline right-of-way during winter one year before pipe installation, and generally during the same period as the borrow and fill activities at the nearby airfields, stockpiles, and campsites. The crews engaged in this work presumably will occupy

temporary, mobile camps at stockpile or other sites along the right-of-way. Clearing will be done with bulldozers although hand clearing will be substituted in sensitive locations. Slash will be piled and burned during the clearing operation.

The principal environmental interactions or concerns that could potentially arise from right-of-way clearing relate to terrain and permafrost disturbance; slope stability and erosion, particularly on approaches to streams and as a result of burning or removal of stumps; cleanup and stabilization of temporary stream crossings and access routes; siltation; disturbance of fish and other aquatic organisms; destruction of critical wildlife habitat; disturbance of mammals or birds by noise; sanitary arrangements at camps; use of merchantable timber; and visual aesthetic disturbance. Salvage archaeology along the right-of-way would be scheduled following the clearing.

Various Summer Activities

During the summer following right-of-way clearing a variety of localized jobs will undoubtedly be required at various sites, involving drainage structures, general tidying of the fills and their surroundings, and completion of camps and their facilities. In addition, concrete weights for control of pipe buoyancy will be fabricated at borrow pits and at sites where gravel has been stockpiled during the previous winter. Construction noise connected with the operations could involve concerns over disturbance of mammals and birds. Also during the summer melt season, drainage and erosion problems together with slumping of fill or disturbed natural ground could be expected at sites, in borrow areas, along permanent and winter roads and perhaps along the cleared right-of-way. These developments, together with work undertaken to repair them, could give rise to various environmental concerns, particularly involving aquatic and wetland habitats.

Mobilization and Stockpiling

The principal activities during the summer before pipelaying will be mobilization of equipment and stockpiling of supplies. This will be a very large operation. For most spreads in the Northwest Territories and Yukon Territory, material will be barged from Hay River down Mackenzie River, off-loaded at the prepared wharves, stockpiled directly at those sites adjacent to wharves, or trucked to more distant stockpile sites via all-weather access roads and/or the Mackenzie Highway. There would be extensive movement of trucks along some sections of the highway system and also through Inuvik, Fort Good Hope, Fort Norman, and perhaps Fort McPherson. This period would also see a very substantial build-up of air traffic in and out of airfields along the pipeline as well as most of those existing at settlements. Expansion of airfields at Fort Good Hope, Fort Norman and Wrigley presumably would have been completed prior to the mobilization period for the relevant spread.

The principal environmental concerns or interactions that could arise from mobilization and stockpiling relate to spillage of fuel or other toxic material, particularly during off-loading of barges or as a result of trucking or barging accidents or leakage of tanks; disturbance of fish and other aquatic organisms; and disturbance of animals or birds by noise.

Installation of Pipe

It is not until all the foregoing activities have been completed that crews can move in to begin the actual ditching and laying of pipe. This

involves an integrated series of winter-time activities carried out sequentially along the right-of-way within the section covered by each construction spread during one work season (about 80 miles). The full process will involve many thousands of vehicle passes at any one point on the right-of-way. The sequence begins as soon as freeze-up permits in the autumn with preparation of a working surface, either as a graded winter road along the right-of-way or, in sensitive permafrost areas, as a snow or ice road. Pipe stringing, ditching, bending, welding, coating, lowering, weighting and anchoring and backfilling follow in sequence.

The principal environmental interactions or concerns that could potentially arise from winter pipe-laying relate to timing of commencement of activities relative to freezing of ground, terrain and permafrost disturbance, slope stability and erosion, blocking or channelling of overland drainage, siltation of waterbodies, spillage of fuel and other toxic substances, source of water for ice roads, disturbance of fish and other aquatic organisms, disturbance of mammals and birds by noise, and archaeological salvage, and lowering of aesthetic values. Terrain disturbance and slope problems involve the ditch zone and backfill, principally prior to chilling of the pipe, and also involve the remainder of the right-of-way in places where construction has lead to scalping, stripping or grading of the ground.

With the exception of six major crossings, placement of pipe beneath river beds is a winter activity. In some rivers there is no winter flow at all but in others water flows throughout the winter either in the channel or through gravel beneath the river bed. Therefore winter installation of river crossings could potentially result in bank instability, river-bed erosion, interruption of water movement in the river bed, and adverse effects on fish or other aquatic organisms.

Pipeline Testing

Immediately after the pipe has been installed in the ground, it is pressure tested using water which, to avoid freezing, may be heated or mixed with methanol. The principal environmental interactions or concerns that potentially could arise from this testing in winter relate to the source of water used for testing, the location and temperature of water discharged, and the effects of the water-methanol mixture, if it were accidentally spilled during handling, or released if the pipe were to rupture during testing. Of course all these concerns relate primarily to water quality, fish and other aquatic organisms.

Clean-up, Restoration, Revegetation

These measures will be applied on the right-of-way, and on roads; at stockpile, wharf and station sites; and in borrow pits. The following comments relating to the right-of-way apply also in a general way to the facilities and borrow pits.

Clean-up will begin in winter as soon as practicable after completion of pipe installation, and will continue into the following spring and summer. Restoration and revegetation will be done during the same period. Clean-up includes burning of combustible wastes, collection of surplus materials, burial of some materials and spreading of surplus soil.

Restoration, in areas of conventional winter construction, includes grading and contouring of the ground and placement of erosion and drainage structures. In areas requiring Arctic construction techniques these procedures will be modified to

protect the insulating cover of organic materials or to replace this cover where it has been removed.

The Applicant proposes to embark upon a program of revegetation during the first few months following installation of the pipe and to continue this program, as required, as part of routine maintenance. Generally, grass seed and fertilizer will be spread from low-flying fixed-wing aircraft or helicopters; the mixture will be adjusted to reflect changes in growing conditions. In some areas, such as hillsides and approaches to rivers, the seed and fertilizer will be applied by crews on the ground. In addition, local shrubs will be planted in some places to promote ground stability.

These spring and summer activities, designed to enhance the environmental and aesthetic acceptability of the project, potentially involve a wide range of environmental concerns or interactions. Basic concerns relate to the short- and long-term effectiveness of the various stabilization and restoration measures and of the revegetation program. Concerns over clean-up methods involve such matters as timing of removal of heavy equipment late in the work season, mode of clean-up of camp sewage and waste-disposal areas, and measures to minimize burial of ice and snow during levelling of the ground.

Restoration of areas with particular non-pipeline land values, such as archaeological sites and sites traditionally used by native people, deserve special attention. Other concerns relate to introduction of exotic plant species, deflection of migrating animals along revegetated areas, effects of equipment noise on the right-of-way during spring and summer on mammals or birds, and disturbance of fish and other aquatic organisms by fertilizer falling directly into water or washing from adjacent land. Moreover, during the first spring and summer following construction the areas of ground that have been disturbed and the associated drainage systems will be particularly prone to further disruption. Particular concerns relate to slope failure, erosion, thermokarst subsidence, backfill instability, blocking of drainage or diversion of drainage, siltation of waterbodies and flushing of toxic material into waterbodies.

Major River Crossings

Major river crossings are installed separately in a manner designed to meet the particular requirements of each crossing. Most are scheduled to be built during the summer following construction of adjoining sections of the pipeline, but the Great Bear River crossing is to be built before the adjacent pipe is layed. The installation comprises a complex series of procedures involving preparation of a ditch down the river banks and across the river bed; stringing and welding the pipe; weighting, lowering and burying the pipe; followed by clean-up, protection of the bank, stabilization and revegetation of slopes, etc. The principal environmental interactions or concerns that could potentially arise from construction of major river crossings are similar to those relating to the minor crossings discussed above, except that the principal activities take place in summer. During construction these could include bank instability or erosion; siltation, velocity changes, and toxic substances in the river with possible adverse effect on fish and other aquatic organisms; as well as disturbance of certain wildlife by noise. Long-term concerns involve integrity of the crossing with possible environmental effects of repairs; aesthetic effect of slope and bank changes, and any ongoing effects on aquatic habitats and fish.

Compressor Station Construction

Following pipe installation, compressors and related facilities are to be built on station pads

built earlier and used for camp and stockpile sites. Some station construction will closely follow on pipeline installation but some is scheduled to be delayed a year or more. Construction involves delivery of considerable quantities of heavy materials including large prefabricated units, foundation preparation, erection of buildings and installation of machinery. Noisy activities and presence of work crews are involved both at the stations and on access routes but all areas would have seen considerable pipeline activity and the stations themselves are areas of ongoing activity and noise. Hence no new environmental concerns are identified.

Pipeline Operation

Operation of the pipeline will be highly automated, with many functions remotely controlled. In-field activities will involve regular servicing of the various facilities (compressors, chillers, valves, measurement stations, monitoring devices, etc.), transportation and storage of fuel and other supplies, movement of personnel, preparations for maintenance and contingency activities, and various aircraft movements. Principal environmental interactions or concerns that could potentially arise from pipeline operation (excluding maintenance and contingency activities) relate to terrain disturbance through build-up of ice around the chilled pipe with possible effects on drainage and fish; effect of compressor noise on wildlife and locally on people; ice fog and other effects on air quality; effect of aircraft noise on certain wildlife; fuel spillage and sewage and waste disposal with possible effects on fish and wildlife.

Maintenance

Maintenance commences upon completion of construction of any part of the pipeline system and will be needed before the pipeline begins operation as well as after. A wide variety of activities are involved but, from an environmental viewpoint, attention focusses on

(i) various changes or hazards that develop along the pipeline which maintenance can avoid or repair,

(ii) the effects of patrolling the pipeline system to locate areas requiring attention, and

(iii) the effects of the repair or maintenance activities themselves.

The principal environmental concerns that could potentially arise from changes or hazards relate to ground stability, drainage, and revegetation along the pipeline itself, on access roads, around the various pipeline facilities as well as in areas disturbed by the project during construction but no longer used on a regular basis. Particularly during the first year or two following construction, there may be ground or backfill subsidence, erosion, slope failure, gullying, ponding, diverted drainage, bank failures, and problems involving fuel storage and waste or sewage disposal; these could raise concerns regarding fish and other aquatic organisms, aesthetics, encroachment on other land use or safety of the installation. In permafrost areas prior to commencement of pipe operation and chilling of the line, there will be concern over the environmental effects of thawing of permafrost, backfill compaction or flowage, and related pipe buoyancy. Following start up, and changing from year to year during the first few years of pipeline operation, there will be different concerns over the environmental effects of freezing of the backfill and unfrozen ground (both naturally unfrozen or former permafrost) potentially involving heave of pipe and ground and drainage changes.

Patrolling activities potentially involve concerns

over disturbance of mammals or birds, and especially the effect of low flying aircraft. Such concerns would relate to particular species in particular places at particular times of year.

The potential environmental interactions or concerns involved in maintenance work and repairs depend on the size, nature, location, and time of year of the work. Most concerns listed in the foregoing part of this chapter could be involved if major repair activities were required in a sensitive area during summer. Most commonly, small jobs could raise concerns over ground disturbance or stability, drainage, siltation and disturbance of fish or other aquatic organisms, local disturbance of sensitive wildlife, and encroachment on other land use. Both the job site and the access routes could be involved.

Contingencies

Contingencies that could potentially occur during pipeline operation include:

(i) pipe failures possibly accompanied by explosion and fire;

(ii) fires in compressor stations or other components of the pipeline system;

(iii) forest or tundra fires;

(iv) slope failures, washouts or floods.

Fires as well as slope failures, washouts or floods could also occur during the construction phase. Environmental concerns that could potentially arise from such contingencies are of three types—those resulting from the "event" itself, those resulting from measures taken to stop or control the "event", and those resulting from repair activities. Environmental concerns over repair activities are referred to above under "Maintenance". Various contingencies could involve direct threats to people, mammals and birds, as well as fish and other aquatic organisms; could lead indirectly to terrain disturbance; and could have adverse aesthetic effects. Actions taken to combat contingencies, which involve movement of men and machinery on an emergency basis, potentially can involve environmental concerns relating to ground disturbance, or disturbance of wildlife or aquatic organisms, depending on the nature of the contingency, time of year, and location.

Abandonment or Inactivation

If and when operation of the pipeline is discontinued, surface facilities would be removed or converted to other uses and the pipeline could either be left in place or removed from the ground. If the chilled pipe were left in place, environmental interactions and concerns could potentially relate to cessation of the chilling process; terrain and aesthetic disturbance could potentially develop along with drainage changes and disturbance of fish and other aquatic organisms. Removal of facilities, and to a much greater degree any removal of the pipe from the ground, would raise environmental concerns similar to those relating to pipeline installation.

CHAPTER 8

PHYSICAL ENVIRONMENT AND ENGINEERING

8.1 CHILLED PIPELINE

Background

Throughout most of the permafrost region, the Applicant proposes to refrigerate the gas and operate the buried pipeline at temperatures below the freezing point of water (32^{o}F or 0^{o}C). This measure is designed to avoid melting the permafrost, thereby avoiding the engineering and environmental problems associated with the thawing of ice-rich permafrost soils. A second advantage is that the decrease in operating temperature would increase the quantity of gas that can be moved through the pipe.

A variety of terrain stability problems could, however, result from chilling a buried pipeline. These problems are related to the natural complexity of the near-surface thermal regime and to the behaviour of water in response to thermal gradients in these near-surface sediments.

The northern part of the proposed route lies within the zone of continuous permafrost as designated by Brown (1967). Within this zone, permafrost is well below freezing. However, beneath lakes and major streams the ground even this far north is unfrozen to depths far in excess of the proposed depth of pipeline burial. Farther south, permafrost not only becomes generally warmer (just below freezing), but it becomes discontinuous. Unfrozen areas become increasingly common until, at the southern limit of the discontinuous zone, permafrost is found only in isolated patches. Superimposed on this broad regional trend are very local variations in the depth to the frost table that are due to variations in vegetative cover, thickness of the organic layer, winter snow cover, and aspect. Chilling of a buried line will therefore subject naturally unfrozen ground to freezing temperatures at various locations along the proposed route. The incidence of this effect will increase southward.

A poorly understood aspect of a chilled and buried line traversing areas of irregular natural ground temperatures is the extent to which thermal equilibrium is attained between the pipe and the enclosing material. Cooling of the surrounding ground is accompanied by addition of heat to the pipe. Insofar as the pipe and the surrounding ground locally reach thermal equilibrium, passage of a buried pipeline through an area of relatively warm and discontinuous permafrost, for example, may result in some freezing of naturally unfrozen ground, as well as some thawing of naturally frozen ground.

Furthermore, in areas of "warm" permafrost, construction activities could induce local thawing of the permafrost, principally by destruction of the insulating cover of vegetation and by excavation. Subsequent refrigeration of the pipe (a year or

years later) would result in refreezing of the ground.

Chilling of the gas will have the desired effect of retaining permafrost in its frozen state. On the other hand, operation of the pipeline at freezing temperatures that are markedly below those of the surrounding material, whether thawed or frozen, will result in negative temperature gradients toward the pipe. Under these conditions water may migrate through the sediment toward the pipe, i.e. down the temperature gradient (Harlan, 1974). In addition, water will migrate to the vicinity of the pipe, down normal hydraulic gradients. The result will be freezing of the water, formation of ice lenses around the pipe, and upward heave of both the pipe and the ground in the vicinity of the pipe. Although the rate of water migration in frozen soil is low, it could produce significant heave over the long operating life of the pipe.

Unfrozen sand and gravel are not subject to growth of ice lenses and heave, but they commonly serve as aquifers, conducting large flows of groundwater. In such materials, development of a bulb of frozen soil around the chilled pipe will restrict groundwater flow and may initiate surface icings (*see* topic "Springs and Icings"). The technical problems of predicting the rate of growth and shape of a frost-bulb under conditions where convective transfer of heat by groundwater is involved are discussed in the Appendix.

The potential magnitude and rate of frost heave under chilling conditions are poorly understood. They are dependent on such factors as steepness of the thermal gradient, soil type and permeability, and availability of moisture. The potential for frost heave appears to be greatest in unfrozen fine-grained sediments. Preliminary geotechnical calculations (Environment Protection Board, 1973) have indicated that the potential heave is sufficient to severely damage the pipe and interrupt surface drainage. Palsen in the region indicate that frost heave of as much as 10 feet has occurred as a result of local moisture migration down natural thermal gradients.

In unfrozen ground, migration of water from surrounding natural soil towards the chilled pipeline will slowly draw water out of the surrounding fine-grained soil, resulting in its considerable desiccation. This phenomenon has been observed during artificial freezing of soils. Khakimov (1966) describes a case where shrinkage cracks up to 1 inch wide were produced by such a desiccation. This effect warrants investigation in connection with pipe stability and the recovery of the vegetation cover on the right-of-way. Also, it is possible that desiccation of a soil containing excess ice could result in minor local subsidence adjacent to the right-of-way.

Ideally, thermal gradients between the buried pipe and the surrounding sediment would be avoided by regulation of the gas temperature so that it matched closely the local temperature of the ground around the pipe. However, the great variability of ground temperature both locally and regionally throughout the permafrost region coupled with limited flexibility in operating temperature (see below) make that ideal virtually impossible to attain.

Applicant's Data

The Applicant is proposing to compress and refrigerate the gas at a series of stations spaced about 40 to 50 miles apart along the pipeline. Owing to physical properties of compressed gas, the gas temperature drops about 15^{o}F between compressor stations then rises abruptly as it passes through the next compressor (*see* Figure). Compressor stations will be phased in over a five-year period, changing the temperature profile with each addition of compressor capacity. At any one point, the gas

emperature will change several times, either up r down (or both) during the five-year period, and ould change further if compressor capacity is in-reased after five years (Note provision for doub-ing of compressor capacity in Typical Compressor tation Configurations (Sect. 8.b.3, Sheet A-1)). long some parts of the pipeline, gas temperature ill fluctuate between freezing and thawing as com-ressors are phased in. For example, at Compressor tation M-17, the predicted station discharge temp-rature is 39.5^0, 29.8^0, 30.6^0 and 35^{0}F for the nd, 3rd, 4th and 5th operating years respectively.

he Applicant's statement on potential frost heave escribes the general physical principles involved n the phenomenon and prediction of its effect Sect. 8.b.1.3.9.4). No assessment is made of the robable extent and magnitude of frost-heave prob-ems. The Applicant's design approach is summa-ized in the following statement, "A conservative pproach will be used in analyzing the problem and n developing the methods for engineering design. his conservative approach will be predicated on he data obtained during a test program under-aken to study the physics of frost heave and shut-ff pressures in the laboratory, and to evaluate he performance in the field of a full scale di-meter pipeline when operated below freezing temp-ratures in a frost susceptible soil. The results rom this program are expected to provide a better nderstanding of the unique features of a chilled s pipeline in unfrozen soils ...."

e Applicant's generalized assessment of the prob-le effects of the buried chilled pipeline on rface and subsurface water flow and the resulting gineering and environmental problems are reviewed sewhere in the present report (*see* topic "Springs d Icings").

Concerns

e environmental effects of chilling a buried gas pipeline will vary greatly along the proposed route depending on soil conditions and on the thermal and hydrologic regimes. The principal concerns identi-fied are discussed below.

Frost Heave

Negative temperature gradients towards the cold pipe will result in the migration of soil moisture to-wards the pipe. This moisture will freeze and re-sult in heave of the pipe and the ground surface in the vicinity of the pipe. This problem will be most severe where the chilled pipe passes through unfrozen fine-grained soils to which an abundant supply of water is available.

No simple, reliable and economically feasible mea-sures are available for eliminating or reducing potential problems of frost heaving associated with the buried chilled line. Some possible measures, such as removal of frost-sensitive soil from be-neath the pipe and replacement by non-sensitive fill, or lowering of the water-table, could result in environmental damage. Substantial heave of the pipe could result in failure of the line if local differences in the amount of heave are extreme, or if support is removed locally through subsequent melting of associated ice lenses.* Damage to the terrain could result from hastily mounted attempts to remedy problems associated with the heave. Furthermore, where the terrain is normally unfro-zen, inactivation or abandonment of the pipeline will result in thawing and ultimate collapse of ground where ice lenses have grown under the in-fluence of the refrigerated line.

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*This possibility is based on observations of degradation of palsen. Degradation is commonly initiated when heave due to ice-lens formation results in development of large cracks that ad-mit warm surface water or expose the ice lens to warm air.

Disruption of Drainage

Heave of the ground surface in the vicinity of the pipeline could seriously disrupt surface drainage by ponding water on the upslope side of the right-of-way. This could be particularly severe where surface drainageways are poorly defined and where surrounding materials are ice-rich and subject to thermokarst development. Local heave could result in concentration of surface drainage with intensification of local soil erosion.

A chilled pipeline will reduce the thickness of the seasonal active layer, particularly in the more southern parts of the route. Seepage of groundwater within the active layer would be constrained and could result in elevation of the water-tables upslope from the right-of-way. This could influence local vegetation and could lead to concentrations of surface drainage.

Disruption of subsurface water flow and its environmental effects are discussed further in the topic "Springs and Icings".

Tensional Stresses in Permafrost Soils

The proposed operating temperature of the chilled pipeline would be considerably below natural permafrost temperatures, particularly in the southern part of the permafrost zone. Reduction of the temperature of the permafrost adjacent to the pipe will induce tensional stress in the frozen soil and could produce tensional cracking. The possible effects on the pipeline of these cannot be predicted readily, but warrant investigation. Orientations of thermal contraction cracks are known to be related to thermal gradients (Lachenbruch, 1962). A chilled pipeline could result in development of a new pattern of frost cracks in the ground. Possible effects of such cracks on drainage and susceptibility to erosion deserve consideration.

Sensitive Terrain Types

On the basis of data supplied by the Applicant, and the results of terrain evaluations conducted under the Environmental-Social Program, the following terrain types are judged most likely to give rise to frost-sensitivity problems adjacent to the chilled pipeline.

(i) Thermokarst glacial lake deposits (Applicant's terrain types GLB-2, DL-TK, DL-BS, DL-PT) that occur at numerous intervals within the discontinuous permafrost zone notably from north of Hanna River intermittently to Oscar Creek, from Great Bear River intermittently to Big Smith Creek, and from Martin River intermittently to Liard River.

(ii) Unfrozen or alternately frozen and unfrozen organic terrain (mainly Applicant's RKM(PT), RKM(BS), GLB(PT)) that also occur at numerous intervals within the discontinuous zone, notably from south of Fort Good Hope intermittently to Chick Lake, and from Liard River extensively to the Alberta border.

(iii) Some areas of glacial lake deposits not classified as thermokarst (Applicant's GLB-1 and DL) are likely also to have significant unfrozen frost-sensitive intervals.

<u>Highlights</u>

1. Chilling of the pipeline to reduce environmental and engineering problems associated with thaw of ice-rich permafrost may lead to different problems associated with ice build-up, heave of the pipe, and drainage disruption.

2. The magnitude and rate of processes that would

result in build-up of ice around the cold pipeline with consequent heave of the pipe and ground surface are poorly understood. The potential for terrain disturbance resulting from these processes is considered to be substantial and to warrant detailed investigation of the processes and their effects.

3. Adherence to the following principles would lessen the potential for terrain instability both during operation of the pipeline and after its abandonment:

(i) location and design of the pipeline such that ground stability is dependent as little as possible on maintenance of permafrost by the refrigerated line;

(ii) regulation of pipe temperature so that it approximates as closely as possible the natural local ground temperature;

(iii) minimizing situations where naturally unfrozen ground is subjected to long-term freezing, and where natural permafrost is thawed and then refrozen.

4. In the southern part of the discontinuous permafrost zone, thawing of permafrost may result in fewer engineering and environmental problems than freezing of naturally unfrozen ground, assuming that the rate of thaw of permafrost takes place under controlled conditions. Consequently, the Assessment Group considers that a reappraisal of the Applicant's plans to operate the pipeline at freezing temperature in the southernmost part of the Northwest Territories (e.g. south of Liard River) would be appropriate.

5. Terrain types that are particularly frost-sensitive and potentially prone to disturbance from the chilled pipeline are listed.

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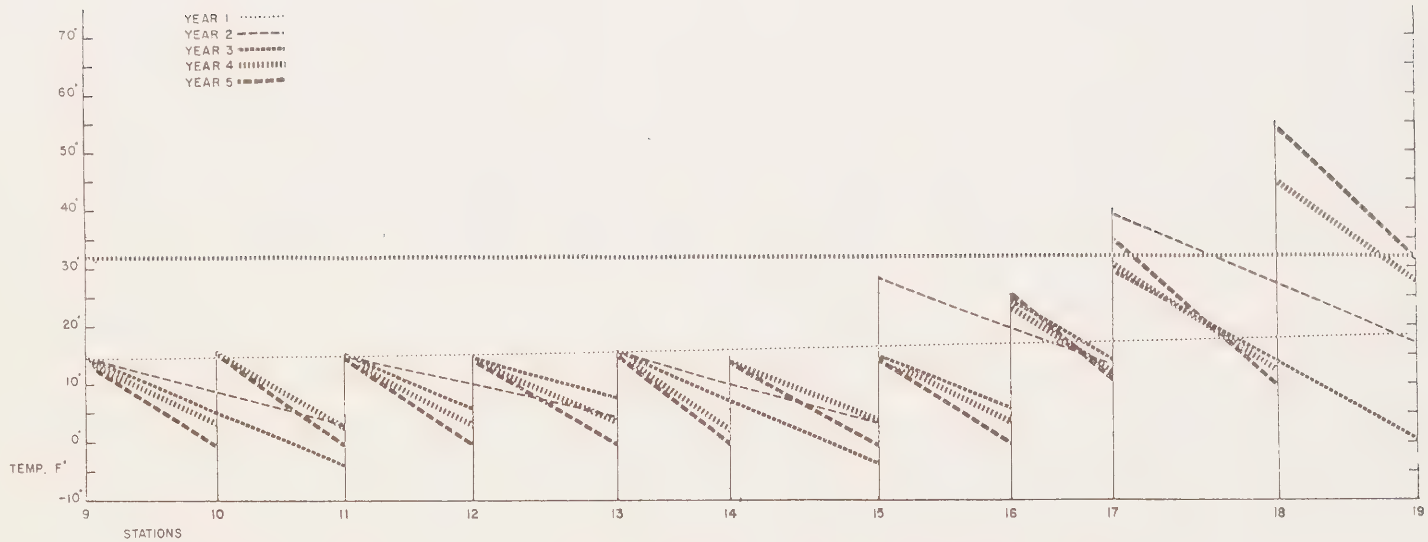

COMPRESSOR STATIONS INLET AND OUTLET TEMPERATURES FROM STATION M-9 NEAR NORMAN WELLS (AT LEFT) TO STATION M-19 NEAR LATITUDE 60^0 (AT RIGHT). LINES BETWEEN STATIONS ILLUSTRATE DIAGRAMMATICALLY THE TEMPERATURE DROP FROM ONE STATION TO NEXT; THEY DO NOT ATTEMPT TO REPRODUCE THE ACTUAL GRADIENTS.

APPENDIX

Effect of Convective Heat Transfer on the Formation of a Frozen Zone Around a Pipeline

The Applicant has developed a computer-oriented method for analyzing the ground-thermal regime around the pipeline (Sect. 8.b.1.3.7). The method is shown to furnish reliable prediction of the position of the thaw (or freezing) front around the pipeline for most boundary conditions. The method is, however, limited only to *conductive* heat transfer, and does not include a term for *convective* heat transfer.

Convective heat transfer is likely to be a significant factor in determining the rate of growth and ultimate size and shape of a frost bulb around the chilled pipeline where it is buried in permeable soils having groundwater flow, for example, in sand or gravel beneath river beds. Because the ultimate size and shape of the frost bulb will determine the degree of interference with groundwater flow and hence the magnitude of such problems as icings, it is important that the Applicant develop a method of geothermal analysis that will take convective heat transfer into account.

Solutions for several problems involving a combination of conductive and convective heat transfer have been shown in the literature. For example, Hrycak (1963) obtained a solution for the solidification of an infinite slab with convective cooling at the surface, by using the heat-balance integral technique. The effect of convective heat transfer due to seepage under temperature gradient on the thawing of frozen earth dams was investigated by Tsytovich *et al.* (1972) using the notion of an effective thermal conductivity.

A solution for the effect of percolating rain water on the rate of thaw of a semi-infinite frozen medium was obtained by Perl'shtein (1968). The solution is valid for rain of a given intensity and temperature and both with and without the formation of a groundwater table.

The problem of the effect of groundwater flow on the formation of a frozen zone around a pipe has drawn considerable attention in the field of artificial freezing of soils (e.g. Khakimov, 1966) and numerical solutions have been obtained for a single pipe and for a row of parallel pipes by several authors (Hashemi and Sliepcevich, 1973; Victor, 1969; Takashi, 1969). A most comprehensive theoretical treatment of the problem was given by Hashemi and Sliepcevich (1973), while Victor also conducted model tests. The following Figures 1 and 2 show some results obtained by calculation and by model tests. It is clearly seen that the distortion of frozen cylinders depends a great deal on the rate of flow and the temperature of the groundwater. It is interesting to note that, according to Hashemi and Sliepcevich, the contribution of groundwater flow to the temperature field is a function of a single dimensionless flow parameter Ω, defined by

$$\Omega = (k_o\ C_f\ L/K_o)\ (dh/dx)_{AB}$$

where

k_o = coefficient of permeability of unfrozen soil, in $ft^3/h \cdot ft^2$;

C_f = volumetric heat capacity of groundwater, in $Btu/ft^{3} \cdot {}^oF$;

L = one-half of centre-to-centre distance between adjacent freeze-pipes, in feet;

K_o = mean thermal conductivity of frozen soil, in $Btu/h \cdot ft \cdot {}^oF$;

$(dh/dx)_{AB}$ = drop of hydraulic potential, assumed constant over the considered distance $\overline{AB}$ perpendicular to the pipe, in ft/ft.

Numerical calculations carried out by the authors show that for $\Omega = 1.162$, the rate of growth of the frozen boundary towards the adjacent freeze pipe is actually greater than for $\Omega = 0$ (no flow) as seen in Figure 1. This apparent anomaly can be explained on the basis of combined conductive and convective cooling. At low flow rates (of the order of 0.01 to 0.02 $ft^3/h \cdot ft^2$) the water gives up heat to the sand formation as it enters the region and absorbs heat as it passes through the unfrozen area around the pipe, thus cooling the sand layer more than it would have been cooled if there were no water flow present. However, higher flow rates (corresponding to $\Omega = 5.81$ in Figure 1, or about 0.50 $ft^3/h \cdot ft^2$) tend to elongate the isotherms in the direction of flow at the expense of diminishing the rate of lateral progression of the frozen boundary.

Figure 2 records results of some model tests carried out by Victor (1969) which show a similar trend. (In Figure 2, t_I is the temperature of the cooling pipe in degrees C, t_{II} is the temperature of the soil and the groundwater in degrees C, and w is the rate of groundwater flow in meters/hour.)

For many Arctic and subarctic streams, there is cyclic seasonal change of flow regimen from a winter condition with no channel flow and deep frost penetration of bottom sediments, to spring flood conditions to a summer low water condition in which expanses of bottom sediment are exposed to solar radiation; there are, therefore, marked fluctuations of the hydrologic regime and of the thermal regime of both water and soil that are not provided for in solutions discussed above. These will complicate the geothermal model and require thermal data not now available for any of the stream crossing sites.

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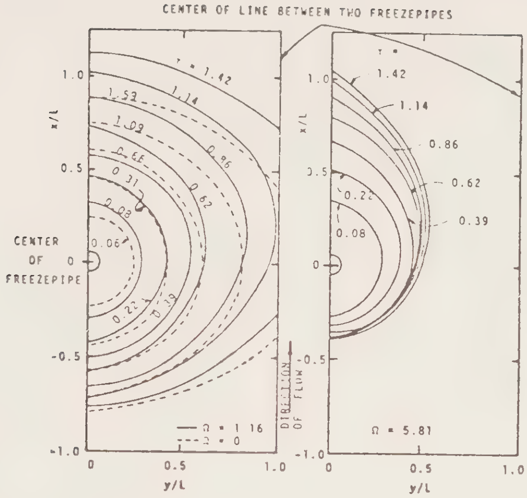
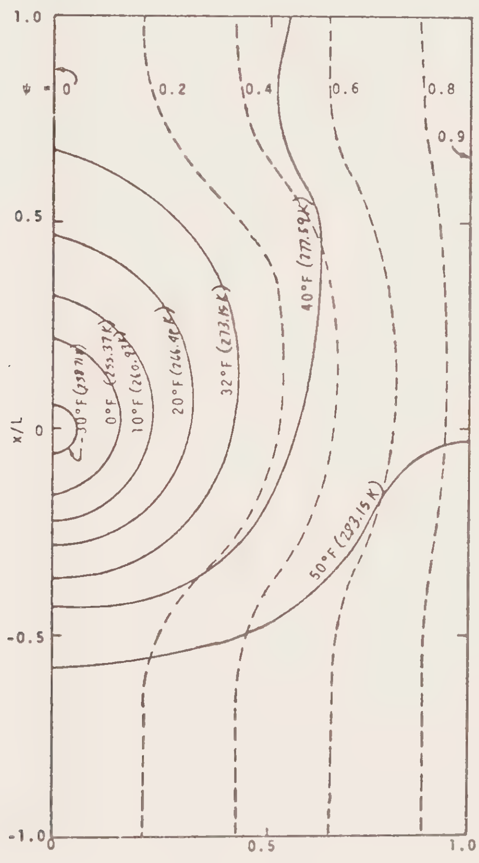


Effects of Ground-Water Flow on Growth of Frozen Soil Boundary Around 6-in. Freeze-Pipe



Temperature and Stream Function Profiles for $\Omega = 5.81$ and $\tau = 0.62$

Ω = dimensionless flow parameter;

τ = dimensionless time = $(K_o t)/(C_f L^2)$;

t = time, in h.

Figure 1. Effect of seepage stream on artificial soil freezing, according to Hashemi and Sliepcevich (1973).

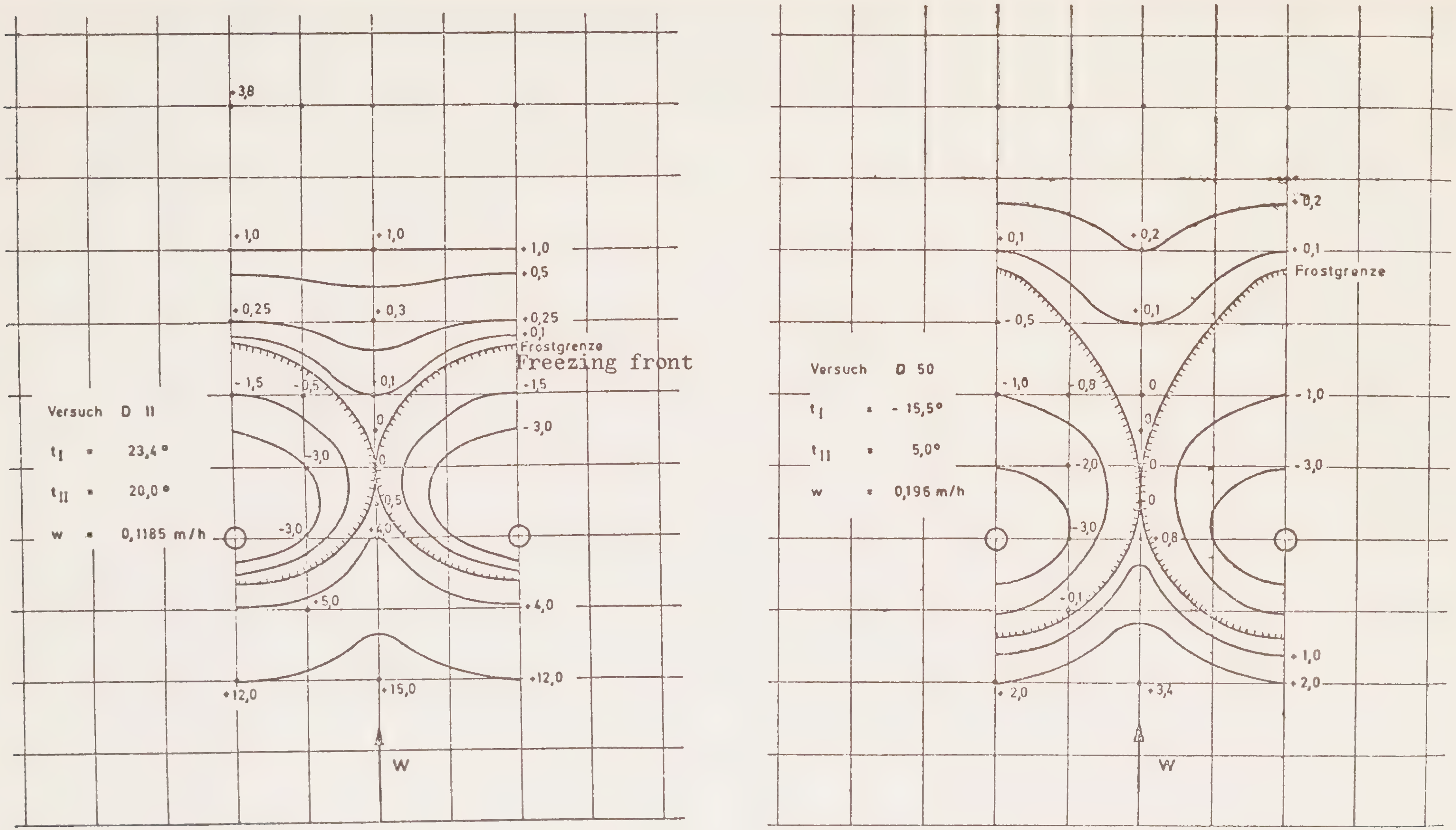


Figure 2. Results of model tests by Victor (1969) on the artificial freezing of soil under the influence of groundwater flow.

8.2 BURIED PIPELINE RATIONALE

Introduction

Gas pipelines may be suspended above the ground surface, may rest upon it, or may be buried beneath it. Most large pipelines in Canada and elsewhere are buried and the Applicant proposes to follow this precedent.

For northern conditions in permafrost terrain, the buried mode may present special problems. The permafrost may melt and, in consequence, various ground-instability problems arise. These include subsidence, erosion, slope failure and groundwater or icing complications. In the case of the proposed gas pipeline, the gas is to be chilled in order to reduce such problems, but it may not eliminate them, and may even aggravate icing problems. Moreover, there will be a very critical period of a year or longer between the commencement of construction and the actual flow of gas before chilling is applied, quite aside from a different class of problems—such as heave and blocked drainage—that chilling might quite separately generate (*see* topic "Chilled Pipeline").

The Applicant proposes to bury the pipeline throughout its entire length—except where it must emerge at compressor and measuring stations and block valves—and provides no comparison with the potential environmental impacts of alternative construction modes. This deficiency of information has been covered in "Requests for Supplementary Information" #24. In the following sections the environmental concerns are explored in greater detail and it is concluded that, for locations appearing to pose particular problems for a buried pipeline, alternative modes of construction may offer advantages. Placing the pipeline on piles or in a berm are possible ways of avoiding certain engineering and environmental problems, and they appear to warrant careful consideration.

Applicant's Data

The Applicant has described experimental facilities where appreciably different modes of pipeline construction have been installed and tested (Sect. 8.b.1.3.5). Three modes were included—full burial or standard ditch construction, burial in a shallow ditch, and above-ground pipe construction. Performance data are reported for the first mode tested—full burial—but none appears for the other two modes and they are not further discussed. However, four important variations on the full burial mode are proposed by the Applicant which are designed to cater to the particular needs of special local conditions. These are:

(i) *sloping of ditch sidewalls*. This variant is proposed in areas of high seismicity where the ditch is cut in bedrock. Backfilling will be done with "non-consolidating" material (Sect. 8.b.1.3.4, p.15);

(ii) *special backfill*. Where the pipeline is to be constructed on slopes, the native backfill material and gradient of which could lead to backfill instability and erosion, special backfill material is envisaged. This will comprise stable granular material (Sect. 8.b.1.3.8.4.1, p.63);

(iii) *slope stabilization procedures*. For "marginally stable" slopes, special stabilization procedures are proposed (Sects. 8.b.1.3.8.4.1, p.63; 8.b.1.3.8.4.2, p.69);

(iv) *deeper burial of pipeline*. Normally the

minimum depth of cover over the pipe will be 2.5 feet both in permafrost and non-permafrost terrain, but deeper burial is proposed where there is need to increase stability against buoyancy, frost heave, differential settlement and erosion (Sect. 8.b.1.3.9.2, p.74).

Concerns

Construction experience in permafrost regions has demonstrated that environmental and engineering hazards accompanying disturbance of the frozen ground are particularly severe where the protective organic mat which covers the ice-rich mineral soil is breached. Pipe burial, of course, involves such disturbance and could lead to slides and earth flows on slopes and ground subsidence on sites of low relief. These phenomena and the processes involved are described in other topic sections of this Chapter.

The Applicant's Arctic construction techniques are designed to reduce ground disturbance in sensitive permafrost areas but will have limited effect on the stability of backfill and natural soil around the pipe itself. The Applicant proposes to chill the pipeline to maintain the ground in a frozen state and thus reduce the possibility of ground failures, but chilling may not be completely successful in achieving stability and certainly will not reduce the hazards either before "start up" of the pipeline, during periods of inactivation, or after abandonment.

In areas of unfrozen ground, chilled operation of the buried pipeline is expected to cause build-up of ice in the soil surrounding the pipe. This change could result in upward heave of the pipe, disruption of movement of water through the ground and a potential for icing effects, ponding, and erosion (*see* topic "Chilled Pipeline").

It is recognized that for most sections of the right-of-way use of erosion-control and ground-stabilization procedures coupled with one or other of the variants of full pipe burial might go a considerable, and perhaps the entire way towards avoiding the engineering and environmental difficulties discussed above. However, uncertainties remain that could be completely dismissed if an above-ground mode of construction were adopted for appropriate lengths of the right-of-way. The above-ground mode of construction has been used instead of or alternated with full burial for pipeline construction in the Arctic regions of other countries, hence appears worthy of close study. Several variants on the above-ground mode exist, ranging from berms of one sort or another to piles. Each has its own characteristics, with strengths and weaknesses in its ability to counteract particular problems.

Highlights

1. The fully buried mode of construction presents special problems in northern areas where soil disturbance may cause the permafrost to thaw and lead directly and indirectly to a variety of engineering and environmental concerns arising from terrain instability.

2. For a fully buried gas pipeline, the problems may be reduced by chilling the gas and by adopting erosion-control and ground-stabilization procedures coupled with one or other of four proposed construction variants, such as deeper burial or using special backfill material.

3. Such procedures, however, may not be successful everywhere, and on unfrozen terrain chilling may generate problems through build-up of ice in soil around the pipe causing upward heave of the pipe and impeding lateral drainage. Moreover, chilling will not commence before a critical one-

to two-year period has elapsed, and cessation of chilling upon inactivation or abandonment may be followed by instability.

4. Some of the problems mentioned above as arising from pipe burial could be avoided by placing the pipe above ground on piles or in a berm. Consequently, the possible advantages of above-ground construction in short environmentally sensitive sections of the pipeline route warrant review, perhaps at the final design stage of the pipeline project.

8.3 TERRAIN ANALYSIS

Introduction

The rock and soil materials through which and on which the pipeline and associated facilities will be built will exert an important influence on pipeline location, design, construction, maintenance and repair. In the permafrost region it is not safe to assume that rehabilitation and control measures after construction will be able to contend satisfactorily with the engineering and environmental problems resulting directly and indirectly from ground disturbance. Rather, it is important to replace "cure" by "prevention" insofar as possible and to anticipate and avoid problems relating to ground conditions in selection of locations, design, and construction control.

The above assumes that all necessary information about ground conditions are known in advance, but it is costly and time-consuming to obtain such information in appropriate detail and particularly so in the North where permafrost and muskeg add greatly to the complexity of the terrain. Obviously it will not be possible to know all in advance, but it is important that the terrain and geotechnical information are wisely selected and are used as effectively as possible.

A considerable amount of terrain and geotechnical information has been provided by the Applicant in the exhibits accompanying the Application of March 21, 1974, and, as highlighted in one of the "Requests for Supplementary Information" prepared by the Assessment Group, a very great deal of additional information has to be obtained for preparation of the Applicant's final design.

In appraisal of the Application and exhibits, the Assessment Group has felt some concern over the adequacy of the terrain and geotechnical information supporting the Application, over the effectiveness of the Applicant's use of this information (or the presentation in the exhibits), and over terrain and geotechnical aspects of proposals for location, construction, ground stabilization, etc. A number of these specific concerns are presented in other topic sections of this report. In contrast, the present section highlights concern over the effectiveness of the Applicant's use of terrain analysis in his documents, and makes suggestions regarding appropriate use of such analysis by the Applicant in final design and in supporting documents that could serve in any governmental review of the final design.

Terrain analysis is the systematic portrayal of the land surface and subjacent materials, and of physical processes active on or below the land surface. Terrain analysis is usually undertaken to assess the capability of the terrain for certain uses, hence the analysis is planned so as to emphasize those factors that bear on the intended uses.

Most terrain analysis has three identifiable aspects: classification, delineation or mapping, and characterization. Any substantial land area has an almost infinite number of terrain types or classes, each differing in some way. Classification consists of grouping these into as few classes as possible while still recognizing distinctions that are important to the intended land uses. The classes must be chosen so that the delineation of boundaries between them, and transfer of the boundaries to maps, can be accomplished within reasonable time at reasonable cost.

Terrain characterization consists of detailed

assessment of the physical character of each terrain class, and includes observations of processes such as erosion, slope failure, degradation or aggradation of permafrost, that bear upon land-use capability and probable engineering behaviour of the class. In particular, characterization does not imply exhaustive detailed study along the entire length of the pipeline route. Rather, it implies *detailed studies of one or more restricted areas within each terrain class* selected to identify the typical character of, and the degree of variation within, the terrain class.

Applicant's Data

The Applicant has provided terrain analysis "based on airphoto interpretation and supplemented by published information, field investigations, and drilling programs" (Sect. 8.b.1.3.6, p.39). The terrain mapping is shown on Alignment Sheets on a photomosaic base at scale 1" to ½ mile which cover a strip 2.6 miles wide, that is roughly 1.3 miles on either side of the pipeline alignment, although locally the alignment lies as little as 0.2 mile from the limit of mapping.

Brief descriptive legends accompany each Alignment Sheet and logs showing soil, permafrost and ground-ice conditions in holes drilled within the mapped strip are provided on the Alignment Sheets.*

*A more detailed description of the terrain units, prepared by J.D. Mollard and Associates for Northwest Project Study Group and Mackenzie Valley Pipeline Research Limited, is available to the Assessment Group. However, the description is based on a proposed route that crosses Mackenzie River at Sans Sault Rapids and extends northwest to and beyond Fort McPherson; it cannot therefore reflect fully terrain conditions on the east side of the Mackenzie River from Sans Sault Rapids to Richards Island. Further, the descriptions prepared in 1971, cannot reflect the extensive data available from drilling programs conducted by the Applicant, and by or for Government Agencies, in subsequent years.

The Applicant has also provided a descriptive summary of geological and permafrost conditions along the route region by region (Sect. 8.b.1.3.2), but without reference to the terrain classification used on the Alignment Sheets and without assessment of the land-use capability or probable engineering performance of the various types encountered.

Permafrost, ground ice and associated phenomena are also described briefly (Sect. 8.b.1.3.3), but again without reference to the Applicant's terrain classification.

Concerns

Appropriate terrain analysis would serve to permit the Applicant to develop his design and to choose his route and locations with maximum cognizance of terrain problems and would permit the reviewer to estimate the probable impact of the project in terms of terrain disturbance. The terrain information provided in the exhibit accompanying the Application does not adequately meet either objective.

1. Although the classification system presented on the Alignment Sheets is appropriate to the project and the region, certain of the terrain classes warrant subdivision in order to bring out critical differences in terrain character. Specific examples are the units designated as RKM, HM, and PT.

2. The mapping coverage has limitations for judging the Applicant's detailed route and site selection and is even more limited for judging broader route selection within the general "corridor". The maps cover a width of 2.6 miles along the route, and in places the alignment lies within 0.2 mile of the limit of mapping. Moreover, numerous surface facilities including roads,

airfields, wharf sites, campsites, communication sites and proposed borrow sites lie outside the limit of mapping.

3. The characterization of terrain is judged to have serious deficiencies described below which severely limit usefulness of the terrain analysis in appraisal of proposals regarding location, design and construction of the pipeline:

(i) only general descriptions of topography of each terrain class are provided on the Alignment Sheets. However, there is no specific information on steepness or lengths of slopes nor on terrain roughness. These factors are critical in identifying location and amount of stripping, grading or cutting required on the pipeline right-of-way, and on permanent or temporary roads and in determining the prevalence of slopes that are potentially unstable or subject to erosion;

(ii) only minimal, qualitative data are provided on the areal distribution of permafrost within the various terrain units, and on the form, amount and distribution of ground ice. Logs of boreholes are provided on the Alignment Sheets but no analysis is provided that would identify and quantify differences between terrain classes;

(iii) descriptions of soils within the terrain classes are mainly qualitative, with little quantitative data on such soil parameters as grain size, plastic and liquid limits, porosity, permeability or coefficient of consolidation. (Note however that grain size and plasticity are implicit in the *Unified Classification* used in the borehole logs);

(iv) only minimal data are provided on the stratigraphy of certain terrain classes that typically have two or more layers, and in which knowledge of the stratigraphy is critical in estimating the probable engineering performance of the units;

(v) descriptions accompanying the Alignment Sheets contain, at most, brief descriptions of the patterns of surface drainage, and no data on the hydrology of the active layer or of unfrozen intervals within the terrain classes;

(vi) only minimal data are provided on physical processes active within terrain classes, such as various types of slope failures, permafrost aggradation and degradation, erosion, etc. or on the differences in kind and degree of these processes in the various terrain classes. Observation of such processes provides an extremely valuable first estimate of the probable reaction of terrain to proposed land uses. Indeed, because of the complexity and inherent uncertainties of geotechnical analysis of permafrost soils, quantified field studies of physical processes may prove in some instances to be more reliable than geotechnical analysis for design purposes;

(vii) the Applicant has not provided a rating of the suitability of the individual terrain classes for construction of the pipeline and surface facilities, according to his proposed design and construction methods.

4. The Assessment Group is concerned not only over inadequacy of the analysis of the terrain and use of terrain and geotechnical data in the

present proposals of the Applicant, but also, over the extent to which the Applicant will overcome these deficiencies in the detailed planning and final design that will follow. The following kinds of information are involved.

(i) photo-mosaic maps at the same scale as the Alignment Sheets showing location of all proposed facilities including permanent and temporary roads that lie outside the boundaries of the Alignment Sheets ("Requests for Supplementary Information" #17), and lateral extension of terrain mapping as required to show a minimum width of 1 mile on either side of the right-of-way centreline;

(ii) for the final design stage, orthophoto maps of the right-of-way, facilities lands and permanent and temporary roads at an appropriately detailed scale and contour interval, and designating such aspects of final design as application of clearing methods, erosion-control revegetation and buoyancy-control measures, and intervals of stripping, grading or cutting;

(iii) sub-division of some terrain classes used in the terrain analysis, in particular (but not limited to) terrain classes RKM, HM and PT;

(iv) characterization of all terrain classes involved in construction of the pipeline and surface facilities. Such characterization would include (but not be limited to):

a) typical landform of the respective terrain classes, and deviations from the norm;

b) typical character (and variation) of the geological materials or soils, including such soil parameters as grain size, plastic and liquid limits, porosity and permeability and coefficient of consolidation. For several of the terrain classes, there are typically two or more distinct layers of geologic materials, each of which may require individual evaluation;

c) typical distribution and thickness of permafrost and typical form, distribution and amount of ground ice;

d) typical patterns (and variations) of both surface and sub-surface drainage;

e) physical processes (either natural or man-induced) that are active within the respective terrain classes, including slope failure, erosion, shifting of stream channels and degradation or aggradation or permafrost.

The characterization would make maximum use of geotechnical data obtained for design purposes, but should include detailed study of one or more restricted sample areas of each terrain class. Sample areas should be chosen to show the typical character of, and the degree of variation within, each terrain class. Further, sample areas should be selected to allow for regional change from south to north in the distribution, form and amount of ground ice, within many of the terrain classes.

(v) An assessment, based on terrain and geotechnical data, of the potential engineering

and environmental problems associated with each terrain class, and making specific reference to proposed design and construction methods for the pipeline and facilities.

5. Pipeline design will have to be prepared from only incomplete terrain and geotechnical information, but much additional information will be available during the construction process. Such information, if adequately documented, will be of value in later stages of the project including restoration, revegetation, maintenance, repair, and abandonment. The Assessment Group places importance on systematic recording of such information and, in particular, on the preparation of a continuous profile of the walls of the pipeline ditch showing rock, soils, ground ice, occurrence of water, etc.

Highlights

1. Assessment of the Applicant's proposals would be expected to answer the following questions.

(i) Are the proposals for design, construction operation, maintenance and abandonment of the pipeline appropriate to the terrain conditions along the right-of-way and at facilities?

(ii) Is the location well chosen in terms of terrain conditions?

In the opinion of the Assessment Group, the terrain and geotechnical information and terrain analysis provided by the Applicant are inadequate to effectively answer these questions. It appears that in some respects the answers would be negative, as is evident from concerns over terrain aspects of design and location cited in other topic sections of this report.

2. The terrain and geotechnical data and terrain analysis *as presented* in the exhibits accompanying the Application appear to be rather inadequate as a knowledge base for the Applicant to have used in making appropriate allowance for terrain conditions in the choice of locations and procedures, even at the present early stage in design.

3. The Assessment Group considers it important that the above deficiencies be overcome in the detailed planning and final design stages of the project through more adequate analysis of terrain and use of terrain and geotechnical data. Specific needs are outlined.

4. The deficiencies and needs presented above reinforce the Assessment Group's concern that a further assessment of the Applicant's proposals be undertaken at the final design stage.

5. A continuous profile of soils, rock, ice, etc. exposed in the walls of the pipeline ditch would provide terrain and geotechnical information of substantial value at later stages in pipeline development.

8.4 ARCTIC AND CONVENTIONAL CONSTRUCTION METHODS

Introduction

Pipeline construction activities require a smooth, firm working surface along the right-of-way and on access roads to permit easy transportation of supplies and operation of the heavy specialized equipment involved in ditching, pipe laying, etc. Because of the widespread swamp and other types of soft ground along many Canadian pipeline routes, pipe installation commonly is carried out in winter when the frozen ground provides support for the heavy equipment. Construction procedures have been developed to promote penetration of frost into the ground beneath working surfaces, to facilitate equipment movement, and to leave the ground in a stable, relatively undisturbed state upon completion of the job.

In the case of the Mackenzie Valley gas pipeline, the Applicant proposes to follow the customary practice of laying the pipe in winter, and outlines "conventional" winter pipeline construction procedures which he will use. Nonetheless, he recognizes that these conventional procedures are unsuitable for use in areas of sensitive permafrost and proposes special "Arctic" techniques for such areas. In the sensitive permafrost areas, the soils are fine-grained and ice-rich and their stability and strength depend upon the lower layers remaining frozen. It is true that in summer the upper so-called "active layer" lying above the permafrost thaws, but that it can do so without the ground losing its stability is explained by the protective effects of the natural vegetation, the surface organic mat or humus and the underlying network of plant roots. If the conventional construction method were applied on such areas, the protection to the terrain would be lost, upsetting the natural heat balance, increasing the thickness of the summer active layer and leading to a variety of environmental and engineering hazards. In the Arctic method, trees and larger shrubs are removed, but great care is taken to preserve the lesser surface vegetation and the organic surface mat over the entire width of the right-of-way, except for the 12- to 15-foot ditch line where the pipe is buried.

Although the Applicant's proposals are clear regarding the purpose of the Arctic construction techniques in avoiding engineering and environmental problems, his statements on *where* they are to be applied involve some uncertainty. The Assessment Group has already prepared "Requests for Supplementary Information" (#27) in this regard. In the absence of reply, the Applicant's proposals are reviewed in the following, and concerns are expressed that point to a need for southward extention of the use of the Arctic techniques.

Applicant's Data

The Applicant indicates (Sect. 13.a.6.1) that his conventional winter construction procedure is, "... normally used in areas where terrain conditions are such that construction can be more easily performed when the surface is frozen sufficiently to provide adequate support for construction equipment." Special Arctic construction procedures are proposed as: "... modified conventional winter construction techniques which are appropriate for sensitive permafrost areas." He adds, "Generally, south of 65 degrees north latitude (approximately Fort Norman), the occurrence of sensitive permafrost is minimal. In this area, therefore, it is expected that there will be limited need for Arctic pipeline construction procedures. Generally, north of 65 degrees north latitude, it is proposed that Arctic pipeline construction procedures will be implemented." (Sect.

13.a.6.1). In Section 13.a.6 the Applicant reviews all phases of his proposed construction in terms of these two types of winter construction. For the following activities he proposes the Arctic construction procedure:

- vegetation clearing
- access road construction (snow roads, winter roads)
- right-of-way preparation (grading)
- pipe ditching
- buoyancy control
- backfill
- clean up
- restoration and revegetation.

The following statements on the preparation of roads and right-of-way working surfaces are particularly important in demonstrating differences between Arctic and conventional winter procedures:

"Snow roads will not normally be used in the conventional winter construction areas. In such areas, all temporary access roads and the right-of-way traffic lane will be winter roads constructed by grading the road right-of-way to form a relatively level roadbed." (Sect. 13.a.6.4.2).

"Conventional Winter Grading - Unless otherwise specified, the contractor will grade the entire right-of-way to provide a working surface for proper performance of the construction work." (Sect. 14.d.N.5.3.1, p.10).

"Arctic Grading - In areas of permafrost terrain where damage to the insulating organic cover will cause surface degradation, cut grading techniques will be avoided wherever practical..." "In these sensitive areas, a fill-grading technique will be used..." "A minimum amount of cut and fill grading will be performed along the ditch centerline to a width sufficient to provide a level working surface for the ditcher operation." (Sect. 14.d.N.5.3.1, p.10).

"In permafrost areas the permanent road right-of-way will be cleared. Trees and slash material will generally be placed under the subgrade of the road..." "Fill grading will be used in permafrost areas using the dump and spread method, i.e., pushing material from the fill embankment to advance the grade." (Sect. 14.d.N.5.3.1, p.8).

"The borrow material will be placed by conventional methods: scrapers, dozers and graders. An end-dump technique may be used in northern construction areas when dictated by environmental considerations." (Sect. 13.a.6.4.3, p.34).

Concerns

The fundamental concern about the Applicant's proposals for special Arctic and conventional winter construction methods is not centred on the techniques themselves, which are standard for permafrost and non-permafrost areas respectively. Rather it is the geographic location — 65°N. Lat. — selected by the Applicant to be the general boundary between them. This is considered by the Assessment Group to be substantially north of its optimum. The Applicant's statement, "Generally, south of 65 degrees north latitude (approximately Fort Norman), the occurrence of sensitive permafrost is minimal." appears to be a serious underestimate of the sensitivity of the terrain south of 65°N. Studies conducted under the Environmental-Social Program, Northern Pipelines, e.g. McRoberts and Morgenstern, 1973; Rutter *et al.*, 1973; Hughes *et al.*, 1973; Zoltai and Pettapiece, 1973; Strang, 1973; Lavkulich, 1973 indicate that extensive areas crossed by the pipeline south of 65°N. should be classified as sensitive. This viewpoint is supported by practical experience to date in constructing the Mackenzie Highway, where a significant number of slope-stability and erosion problems have arisen, even though construction methods have been essentially similar to those proposed by the Applicant as Arctic construction. The viewpoint is

further supported by a summary of borehole results (Environment Protection Board, Drawing DT5-G5), which shows that of borings made between 62°30' and 64°15' N., 73 per cent to 90 per cent were in permafrost (depending upon terrain class) and 47 per cent to 62 per cent encountered excess ice.

Particular concern arises from the Applicant's proposal to apply conventional winter construction procedures for the preparation of the right-of-way and for the construction of both temporary and permanent roads in the area between 65°N. and the provincial boundary (60°N.). As indicated above, these procedures involve stripping and grading the ground surface, both on roads and right-of-way, thus removing protective surface materials and hastening the penetration of frost to provide a solid working surface. If applied in permafrost areas, this removal of the surface insulating layer over ice-rich soil would permit the penetration of summer heat beyond the depth of the normal active layer; permafrost would melt, and the terrain could become unstable. Replacement of these procedures by Arctic construction methods, using snow and ice working surfaces, minimizes stripping and grading and thereby preserves the insulating ground cover. Increased thawing of the active layer is avoided and the ice-rich permafrost materials are maintained in their naturally frozen stable state. Thus, it is important to avoid stripping and grading by using Arctic construction techniques for all roads and sections of right-of-way where ground is sensitive to surface disturbance.

In the discontinuous permafrost terrain that characterizes the area between 65°N. and the Alberta boundary at 60°N., prior and unequivocal identification of those sections of road or right-of-way, where conventional winter grading techniques could lead to troublesome permafrost effects and erosion, is both difficult and expensive. The Applicant provides no criteria for such identification, either by reference to his terrain typing or to parameters such as soil type, ground-ice content or slope. His terrain analysis — or the terrain characterization aspect of it — is inadequate to indicate, even in a general way, where stripping, grading and cutting would be environmentally acceptable. Techniques are available for determining the stability of slopes and their potential for permafrost degradation, but these require field sampling and laboratory analysis that are prohibitively expensive for application on an interval-by-interval basis along the pipeline route, or along permanent, temporary or winter roads. Moreover, certain fine-grained but low-ice-content permafrost soils are susceptible to erosion, even though they are not otherwise classifiable as sensitive. In all such sensitive soils, Arctic construction techniques would permit the natural vegetation, the surface organic layer and the underlying root network to play an important role in minimizing water erosion. Conventional construction techniques would exclude this possiblity.

The exhibits accompanying the Application leave unclear whether Arctic and conventional construction techniques will be applied on a spread-by-spread basis, or whether it is intended to alternate from one technique to the other on a mile-by-mile basis within a spread in response to local terrain conditions. In the latter situation, design specification on alignment sheets would have to show areas where special Arctic construction techniques are to be applied. In both cases, however, the distribution of the various erosion-control and revegetation methods indicated in the present Alignment Sheets would have to be adjusted to allow for the higher erosion hazard resulting from conventional construction. It may be noted that the Applicant's statements on erosion control do not differentiate between (a) those areas where stripping and grading is proposed for the full width of the right-of-way and (b) those where Arctic construction procedures will protect the right-of-way surface with snow roads (except along the actual ditch zone).

Highlights

1. The Applicant recognizes that conventional winter construction techniques are unsuitable for sensitive permafrost terrain. For such areas, with their unique engineering and environmental problems, he proposes a special Arctic modification.

2. The Applicant indicates that, south of 65°N., the occurrence of sensitive permafrost along the route is minimal, hence the need for the Arctic technique here will be limited.

3. The Assessment Group considers that the Applicant has greatly underestimated the amount of sensitive terrain south of 65°N. and that any general use of conventional winter construction procedures between 65°N. and 60°N. could lead to substantial terrain disturbance. This concern stems from the stripping and grading procedures used as part of conventional winter construction and applies to both the right-of-way and access roads. Soil types that are of concern include not only sensitive permafrost with high-ice content, but fine-grained soils of lower-ice content, and even some non-permafrost soils where removal of the vegetation can cause an erosion hazard. In contrast, the special Arctic techniques avoid stripping and grading and utilize snow and ice roads and work surfaces designed to protect the ground.

4. In view of the foregoing, the Assessment Group considers the potential for ground disturbance, erosion, and associated environmental effects would be substantially reduced if Arctic construction techniques were adopted as the standard for all construction spreads working north of 60°N. If this approach were adopted, conventional winter procedures, based upon specific terrain data, could be specified for selected stable areas.

5. The Applicant's conventional winter construction procedures involve stripping and grading the full width of the right-of-way. For some areas, terrain hazards might be reduced by narrowing the width of the area disturbed.

6. Conventional winter construction procedures will cause a greater erosion hazard than the special Arctic construction techniques, but the Applicant's erosion-control proposals do not distinguish between these construction measures. Some adjustment in the distribution of the various erosion-control measures designated in the Alignment Sheets to differentiate between areas of conventional and Arctic construction could improve the effectiveness of these controls. Moreover, analogous adjustments in the revegetation proposals could increase their chances of success.

Literature Sources

The following were prepared for the Task Force on Northern Oil Development, Ottawa:

Hughes, O.L. *et al.*, 1973. "Terrain Evaluation with Respect to Pipeline Construction, Mackenzie Transportation Corridor, Central Part, Lat. 64° to 68°N.", Rept. 73-37.

Lavkulich, L.M., 1973. "Soils—Vegetation—Landforms of the Wrigley Area, NWT", Rept. 73-18.

McRoberts, E.C. and N.R. Morgenstern, 1973. "A Study of Landslides in the Vicinity of the Mackenzie River Mile 205 to 660", Rept. 73-35.

Rutter, N.W. *et al*, 1973. "Terrain Evaluation with Respect to Pipeline Construction, Mackenzie Transportation Corridor, Southern Part, Lat. 60° to 64°N.", Rept. 73-36.

Strang, R.M., 1973. "Studies of Vegetation, Landform and Permafrost in the Mackenzie Valley: Some Case Histories of Disturbance", Rept. 73-14.

Zoltai, S.C. and W.W. Pettapiece, 1973. "Studies of Vegetation, Landform and Permafrost in the Mackenzie Valley: Terrain, Vegetation and Permafrost Relationships in the Northern Part of the Mackenzie Valley and Northern Yukon", Rept. 73-4.

8.5 SLOPE STABILITY AND EROSION SUSCEPTIBILITY

Introduction

General

Loss of aesthetic and environmental values could result from slope failures and increased erosion by running water associated with pipeline development. In addition to the aesthetic impact of these scars on the landscape, removal of vegetation and downslope movement of sediment commonly leads to increased siltation of lakes and streams with consequent deterioration of aquatic environments.

Several factors influence the natural ability of the terrain to resist slope failures and erosion by running water: (a) the vegetation root mat that bonds the upper soil layers; (b) natural cohesion of the surface sediment; (c) thermal condition of surface material; (d) concentration of surface water flow; and (e) natural slope. Construction activities that change these properties will affect local stability of the terrain.

This is an area where the concern for aesthetic and environmental values converges with the Applicant's concern for continuity of operation and avoidance of costly repairs. Large-scale earth movement, whether natural or induced by pipeline-related activites, could rupture the line. Uncontrolled erosion by running water could leave the pipe unsupported and subject to rupture under its own weight. Therefore, in location, design, construction, and maintenance of a pipeline, the economic interest of the Applicant is closely parallel to the environmental and aesthetic concern.

While the ultimate consequences to the environment may be similar, the distinction between slope failure and erosion by running water is important because they occur under different sets of conditions and they require quite different management procedures.

Slope Failure

Naturally occurring slope failures along the pipeline route are of three general types:

Shallow Failures. This type of failure is very common in the Mackenzie Valley and northern Yukon where perennially frozen fine-grained materials underlie the slopes (Hughes, *et al.*, 1973). Thawing of the active layer commonly results in a saturated mantle of unconsolidated fine-grained material overlying the impermeable frozen material beneath. This surface layer "detaches" and flows downslope, exposing frozen material in the slope and resulting in more thawing.

Retrogressive-Thaw Flow Slides. These are common along the proposed pipeline route from Fort Simpson north (Hughes, *et al.*, 1973). Commonly initiated naturally by a shallow failure exposing ice-rich soil, they are characterized by melting and downslope flowage of soil. Scars are bounded by steep, arcuate headwalls several feet high that may melt backward for decades at a rate of 50 to 100 feet a year. Sidehill cuts made in ice-rich fine-grained soil could easily initiate such failures. Large retrogressive-thaw flow slides have been known to develop in ice-rich soil after removal of the tree and shrub cover, even though the moss layer and root mat was not removed.

Deep-Seated Failures. These occur in weak shales or where thick permeable sediments overlie silt and clay, and are typically related to oversteepened river banks. Massive blocks of material

move downslope, commonly with backward rotation.

In addition to the above failure modes, the long-term downslope creep of frozen ice-rich soil may locally be a significant form of slope failure.

Slope failures, once initiated, can be very difficult to arrest. The obvious threat that slope failures pose for the pipeline can be minimized by careful initial selection of the route to avoid naturally and potentially unstable areas. Where it is necessary to work on potentially unstable slopes every consideration should be given to maintaining the thermal stability of the materials and altering the natural slope as little as possible.

Erosion Susceptibility

There are several processes by which individual soil particles can be entrained and transported away, but along the proposed pipeline route the erosive power of running water is judged to be the most important.

Soils along the proposed route vary greatly in their ability to resist this erosion. The dominant factor in this resistance is the bonding provided by the vegetal root mat. Natural erosion is virtually restricted to non-vegetated channels, bare slopes, and to severely burned areas; man-induced erosion is almost invariably the result of activities that result in loss of, or severe damage to, the vegetation and the root mat. Concentration of surface-water flow, initiation of slope failures, or direct removal of the surface layer can all produce this effect. Unchecked erosion can expose underlying and adjacent materials to thermal degradation and could lead, in turn, to the initiation of more widespread slope failures and thermokarst development.

Applicant's Data

Burial of the pipeline, as proposed by the Applicant, requires the destruction of vegetation over a width of 12 to 15 feet along the entire length of the pipeline; furthermore, the entire width of the right-of-way south of 65° N. would be stripped and graded. Additional stripping would be required for permanent roads and borrow pits.

The Applicant has stated that the present alignment of the pipeline has avoided slopes which appear to be only marginally stable (Sect. 8.b.1. 3.8.2, p.49). However, his description of a method of slope-stability analysis for shallow failures indicates that stability analyses will be made "where slope instability is suspected" and states "if a slope is found to be potentially unstable, either the pipeline route will be altered or special slope stabilization measures will be specified" (Sect. 8.b.1.3.8.2.4, p.50). General principles of slope stabilization, and brief descriptions of possible applications are described in Section 8.b.1.3.8.4.2 (p.69-71). Use of vertical sidehill cuts, as practised in Alaska, is described in Section 13.a.6.8, p.59.

The general design and application of erosion-control measures are described in Section 8.b.1. 3.8.4.1, p.60-65. Erosion-control categories used in specifying erosion-control measures on the Alignment Sheets are described in Section 8.b.1.3.8.4.1, p.65-68. Four "standard" categories (EC-1 to EC-4) are determined by whether the soil is erodible (unconsolidated) or non-erodible (bedrock) and by whether the slope is between 0° and 3° or greater than 3°. An additional four special categories (EC-5 to EC-8) are provided for special terrain and construction conditions.

Concerns

1. The Applicant places inadequate emphasis on route relocations and different construction methods as ways of minimizing the potential for slope failure and erosion problems. Rather, the strategy is weighted towards various methods that will lessen the negative effects of the proposed, fairly uniform, construction methods along the proposed route. The proposed route has considerable potential for slope failure caused by removal of vegetation or by sidehill cutting, and for erosion due to concentration of surface drainage.

2. Five main concerns are related to slope stability along the proposed route:

(i) a number of slope-stabilization techniques, some applicable to both permafrost and non-permafrost areas and others to permafrost areas only, are described in very general terms in Section 8.b.1.3. 8.4.2. Slope stabilization in non-permafrost areas, following well-proven practices, will not present unusual problems provided that potentially unstable slopes are identified through adequate geotechnical investigations. Slope-stabilization measures proposed for permafrost areas, however, are described in such general terms that the Assessment Group is unable to judge their probable effectiveness. Specific slope-stabilization measures are outlined for only one slope (southern approach to Great Bear River), and criteria are not provided regarding their application under actual field conditions. The Applicant has reported a shallow failure of an ice-rich slope at an inactive test-pipe installation at Sans Sault Test Facility, and has noted that suitable drainage- and erosion-control measures would have prevented this instability. However, data are not provided on soil conditions at the site, or on pre-construction stability as indicated by the Applicant's slope-stability analysis. Nor is there any statement on how such data might have been used in designing slope-stability measures;

(ii) the Applicant has described a method of slope-stability analysis applicable to shallow slope failures (Sect. 8.b.1.3. 8.2.4, p.54). However, the analysis involves costly field sampling and laboratory testing and clearly cannot be applied to all slopes. Moreover, a critical parameter in the analysis, the coefficient of consolidation, may be very difficult to determine owing to inhomogeneity of ice distribution in originally frozen soil (Appx. I). The Applicant has not identified the criteria that would be used in determining which slopes along the route require stability analysis, nor the kind and amount of sampling and testing that would be required for the analysis ("Requests for Supplementary Information", #19). The criteria adopted by the Applicant must, of economic necessity, involve trade-offs between higher expenditure for pre-construction engineering, and the probability of failures with attendant direct costs to himself and indirect environmental cost to the public (Appx. II). The Applicant provides no basis by which the Assessment Group can determine whether or not the trade-offs are appropriate and in the public interest;

(iii) no criteria are provided for recognition of slopes having potential for retrogressive-thaw flow slides or for headward

enlargement of shallow failures by progressive thawing. No control measures are proposed to counteract progressive enlargement of these failures;

(iv) the Applicant has noted that, in areas of permafrost, particularly where the soil is fine-grained, cutting of side slopes can cause permafrost degradation. Accordingly, filling techniques would be utilized to counteract this thawing (Sect. 13.a.6.5.1, p.39). On the other hand, the Applicant has indicated (Sect. 13.a.6.8, p.59) that "Where side hill cuts are required in permafrost, they may be made vertically, so that the resultant thaw and slumping over of the vegetative cover will produce a stable slope. This practice is in general use in highway construction in Alaska..." This practice has been employed mainly in unglaciated central Alaska and north-central Yukon where soil and ground-ice conditions are different from those of the glaciated Mackenzie Valley, Mackenzie Delta and Yukon Coastal Plain. The slopes become stabilized after one or two thaw seasons by repeated small shallow slope failures and minor soil flowage. Pufahl, Morgenstern and Roggensack (1974) have described the performance of six major cuts along a part of the Dempster Highway, Yukon Territory, that crosses unglaciated terrain. Of the six cuts, one developed into a retrogressive-thaw flow slide with a steep headwall, requiring emplacement of a thick gravel blanket to establish stability. This indicates that even in unglaciated terrain problems may arise from uncritical use of vertical sidehill cuts. In the glaciated Mackenzie Valley, Mackenzie Delta and Yukon Coastal Plain areas, where long-lived retrogressive-thaw flow slides are common and widespread, sidehill cuts (whether vertical or sloped) require extreme caution;

(v) the Applicant has not considered the possible effect on the pipeline or other structures of long-term downslope creep of frozen, ice-rich soil (Appx. III).

3. Four main concerns are related to erosion-control measures along the proposed route:

(i) descriptions of particular erosion-control measures are too general to judge their probable effectiveness;

(ii) use of arbitrarily chosen slope and erodibility classes to determine design and application of erosion-control measures could lead to either over-design or under-design depending upon the terrain types to which they are applied;

(iii) the standard erosion-control measures are applied regardless of whether the root mat has been retained or stripped, yet the root mat is the most important single factor influencing local susceptibility to erosion; and

(iv) although river-valley walls comprise a large proportion of the potentially erodible slopes along the route, erosion-control measures are not specified for many of these valley walls.

Highlights

1. Advantages can be gained at the final design stage by shifting emphasis in dealing with slope failure and erosion control toward prevention

rather than cure. This would require management of potential failures at each successive planning stage rather than deferring problems to the next stage. The following would be involved:

(i) reassessment of location of the pipeline and access roads particularly at valley crossings, in order to avoid slopes that may be subject to failure or erosion as a result of construction disturbance. Such a reassessment would be based on terrain characterization (improved, as recommended in the topic "Terrain Analysis"), supplemented by site investigations as required;

(ii) investigation of possible use of "passive" above-ground construction modes on potentially unstable or erodible slopes where such slopes cannot be avoided by relocation; and

(iii) minimizing removal of vegetation in order to reduce reliance on revegetation and other slope-stabilization and erosion-control measures.

. Several considerations would reduce the potential for disruptive slope failures:

(i) minimum reliance on slope-stabilization measures in permafrost areas, except where their effectiveness can be demonstrated by extensive field testing or engineering case histories;

(ii) reappraisal of the principles and criteria used in determining which slopes along the route require detailed stability analysis, and the kind and amount of sampling and testing that would be required for the analyses (Appx. II);

(iii) identification of limiting conditions for development of retrogressive-thaw flow slides and multiple retrogessive flows, using geotechnical and geomorphic analysis to make case-history studies of currently or recently active examples. This would make it possible to avoid slopes having soil and ground-ice conditions indicating potential for these types of failures. Contingency plans would be needed for control of such failures at a very early stage in the event that they develop;

(iv) minimum use of cuts and avoidance of use of either vertical or sloped side-hill cuts or grade cuts; and

(v) determination of possible effects on the pipeline and other structures of long-term downslope creep of frozen ice-rich soil (Appx. III).

3. Several considerations would reduce the local susceptibility of the terrain to erosion:

(i) reappraisal of erosion-control measures, in terms of local terrain types, slope conditions, and proposed construction methods;

(ii) specific design of erosion-control measures to meet conditions on valley walls and river approaches on an individual site basis.

(iii) design and selection of erosion control measures based on field observation of erosion (both natural and man-induced) on the various terrain types crossed by the pipeline. Separate criteria would be applied to intervals where the entire

right-of-way will be stripped and graded, and to intervals where only the ditch line will be stripped.

Literature Sources

Hughes, O.L., *et al.*, 1973. "Terrain Evaluation with Respect to Pipeline Construction, Mackenzie Transportation Corridor, Central Part, Lat. 64° to 68°N.", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-37.

Pufahl, D.E., N.R. Morgenstern, and W.D. Roggensack, 1974. "Observations on Recent Highway Cuts in Permafrost", Environmental-Social Program, Northern Pipelines, unpub. report, 121 p.

APPENDIX I

The Importance of the Coefficient of Consolidation in Slope-Stability Analysis

According to McRoberts, 1972 (*see* also Sect. 8.b.1.3.8.2.5, p.55) the factor of safety F for a completely saturated surface layer of thawed soil on a given slope (angle β) depends on such physical and mechanical properties as the density of the soil, its thermal properties (the rate of thaw α) and its coefficient of consolidation c_v. Of the three sets of properties, the former two usually vary only within very narrow limits. For the value of c_v, however, variations in the order of magnitude can be expected (McRoberts and Morgenstern, 1973, p.29). The sensitivity of the factor of safety to c_v can be deduced from the equation on p.55, Sect. 8.b.1.3.8.2.5. Expressing, in the equation, R by α and c_v, one gets for the ratio of safety factors corresponding to two different values of c_v, all the rest being equal,

$$F_2/F_1 = \frac{\alpha^2/c_{v1} + 1}{\alpha^2/c_{v2} + 1}$$

For example, a typical value for α for the Mackenzie River silty clays is 0.04 cm/sec$^{\frac{1}{2}}$ and for $c_v = 5 \times 10^{-4}$ cm^2/sec (McRoberts and Morgenstern, 1973). This gives $\alpha^2/2c_{v1} = 1.6$. If we assume that the value of $c_{v2} = 0.5c_{v1}$ we get $\alpha^2/2c_{v2} = 3.2$, and the safety factor ratio will be

$$F_2/F_1 = \frac{1.6 + 1}{3.2 + 1} = 1/1.58 = 0.635$$

For an order of magnitude difference in c_v, i.e. $c_{v2} = 0.1c_{v1}$, one gets

$$F_2/F_1 = \frac{1.6 + 1}{16 + 1} = 1/6.5 = 0.153$$

This simple calculation shows that the factor of safety of a thawing slope, which fails due to excess pore pressure at the thaw line, depends a great deal upon the value of the coefficient of consolidation, c_v. This means that, in order to estimate the stability of a thawing slope, one should have a fairly accurate knowledge of the true in-situ value of c_v. Unfortunately, the value of c_v is difficult to determine, in particular its in-situ value for a thawed soil which, on a large scale, may be very inhomogeneous and anisotropic due to its original ground-ice distribution.

Therefore, the way in which the field c_v value will be determined and the number of actual large-scale measurements that will be made at a particular site, are critical to the reliability of slope-stability analysis. If, on the other hand, c_v is only estimated from other physical properties of the soil, the reliability of such estimates should be demonstrated.

Literature Sources

McRoberts, E.C. 1973. Discussion, Proc. Can. Northern Pipeline Res. Conf. Ottawa, NRC Tech. Memo. 104, pp.291-295.

McRoberts, E.C. and N.R. Morgenstern, 1973. "A Study of Landslides in the Vicinity of the Mackenzie River, Mile 205 to 660", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-35.

APPENDIX II

Probability of Slope Failures

The Applicant proposes to limit all future more detailed stability analyses only to the slopes exceeding three degrees that occur along about ten per cent of the route. While the limit of three degrees may be of considerable statistical value, being based on a great number of observations, failures of slopes of less than three degrees remain nevertheless a distinct possibility. In other words, while such slopes may have a high factor of safety against failure, their probability of failure is, nevertheless, small but finite. The same is valid clearly also for the slopes which will be reanalyzed and designed to satisfy the requirement of a minimum factor of safety.

On page 55 (Sect. 8.b.1.3.8.2.4) the Applicant states that "A low factor of safety will normally be employed and a higher value used if the slope conditions are less well known." While this is a proper thing to do in general, no value of the factor is given and it is not explained how its value will vary with the statistical reliability of the slope data.

Because some slope failures will inevitably occur, it is important that the Applicant should define an acceptable level of frequency of failure. Geotechnical investigations and slope analysis could then be planned to achieve at least the minimum standard in final design. The standard selected should be justifiable on the basis of a comparison of the cost of geotechnical investigation and analysis required to achieve that standard, *vs.* the cost of repair of eventual failures plus the cost to the public in loss of aesthetic and environmental values.

An analysis of the probability of slope failures along the entire route, based on the statistical reliability of basic geometrical and geotechnical data *now available*, would show what frequency of failure could be expected if design were to be based on that data. The extent of additional geotechnical investigations that would be required to meet the standard adopted for final design could then be assessed.

The physical character of the soil, the distribution of permafrost and the amount and distribution of ground is relatively homogeneous in some terrain types, and highly inhomogeneous in others. For this reason, statistical reliability of geotechnical data varies greatly from one terrain type to the next. It is important, therefore, that in any one test of the statistical reliability of data, or in analysis of the probability of slope failure, the data from the different terrain types be treated as separate statistical populations.

The general principles stated above apply in general to establishing the allowable limits of differential settlement of pads, or of frost heave around the chilled pipeline, and planning of geotechnical investigation to achieve these limits.

Literature Sources

Höeg, K. and R.P. Marurka, 1974. "Probabilistic Analysis and Design of a Retaining Wall", Proc. ASCE, Vol. 100, GT3, pp.349-366.

Kreuzer, H.L., 1973. "A Probability-Based Safety Factor Approach for Arch Dams", Water Power, Dec. 1973, pp.458-463.

Wu, T.H., 1974. "Uncertainty, Safety and Decision in Soil Engineering", Proc. ASCE, Vol. 100, GT3, pp.329-348.

APPENDIX III

Creep in Frozen Soils

The Applicant recognizes (Sect. 8.b.1.3.8.2.3) that mass movements can occur in frozen slopes and considers creep of frozen slopes and deep-seated failures as possible types of failure in frozen soils. He also recognizes that, in order to analyze quantitatively the stability of a particular frozen slope, a substantial amount of field investigation will be required. He considers, however, that such cases will be rare along the proposed route and proposes the use of special measures intended to insure pipe integrity on frozen slopes in which creep is anticipated.

Taking all conditions but the temperature equal, a frozen slope is clearly more stable than an unfrozen slope, at least for short-term considerations. Nevertheless, frozen slopes in very ice-rich soils may be expected to behave as if they were composed of a pure ice, i.e., similar to natural glaciers. Since the latter are known to descend the slope at a more or less constant rate, the same may be expected to hold also for frozen ice-rich slopes. In principle, therefore, if such a creeping slope contains a pipe fixed at its ends, i.e., which cannot freely follow the slope movement, some transfer of stresses from the creeping soil to the pipe will occur and may bring about the failure of the pipe. The amount of this stress transfer depends mainly on the rate and the amount of movement of the soil relative to the pipe and the adfreeze bond between the frozen soil and the pipe.

It can be shown that, in reality, the rate of creep of a typical frozen slope will be much less than that of an average glacier. This is due to the fact that the creep rate is approximately proportional to the thickness of the creeping layer to the power of 4 or 5 (Paterson, 1969).

Assuming for the ice a flow law of the form

$$\dot{\varepsilon}_{xy} = A\tau_{xy}^{n} \qquad (1)*$$

where $\dot{\varepsilon}_{xy}$ is shear strain in years^{-1}, τ_{xy} is shear stress in bars, and A is a constant in year^{-1} bar^{-n}, and assuming a laminar plane-strain flow of ice without base slip, the creep velocity at a distance y above the base of a glacier of total thickness h, is equal to (Nye, 1952 and 1965; Paterson, 1969):

$$u_y = \frac{2A\tau_b^n h}{n+1}\left[1 - (1-y/h)^{n+1}\right] \qquad (2)$$

When $y \sim h$, (e.g., for a shallow pipe), Eq. (2) reduces to

$$u_y \approx u_s = 2A\tau_b^n h/(n+1) \qquad (3)$$

where τ_b is the shear stress at the base,

$$\tau_b = \gamma h \sin\beta, \qquad (4)$$

γ is the bulk density of frozen soil, and β is the slope angle. For example, taking Glen's values of the constants valid for ice (Paterson, 1969, p.88), namely $n = 4.2$ and $A = 0.148\ y^{-1}\ \text{bar}^{-4.2}$, one finds from Eq. (3) for a 20-m (66-ft) thick layer of ice-rich frozen soil ($\gamma = 1.2\ t/m^3$), creeping down a slope with $\beta = 5^0$, that the creep velocity close to the surface is equal to

$$u_s = 1.62 \times 10^{-3} m/year = 0.0638 \text{ inch/year}.$$

This means that about 15 years will be necessary for the creep displacement to attain 1 inch. The resulting mobilization of adfreeze bond between the soil and the pipe will be very slow, which

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* A and n are both experimental parameters determined from creep tests on ice.

justifies in such a case the use of long-term adfreeze strengths for the evaluation of additional stresses in the pipe.

In the final design it would be appropriate to prepare theoretical solutions for creep and failure of frozen slopes and for the mechanism of stress transfer from the soil to the pipe in a creeping mass. The effect of supercooled bulb surrounding the chilled pipe in frozen soil should also be considered. Some typical frozen slopes susceptible to creep should be instrumented for long-term monitoring of the creep displacements, and the build-up of stresses in the pipe.

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8.6 VEGETATION CLEARING

Introduction

In the Yukon and Northwest Territories land-use developments usually start with clearing the vegetation. The areas affected may be small—as with helicopter landing pads, or they may be substantial—as with the Mackenzie Highway. Two features of such vegetation clearing are of concern. One is the loss of the area cleared, with its merchantable timber, habitat for wildlife, and possibly rare or endangered plant species. The other is the clearing operations themselves. These may be by hand or machine, but in both cases special care is needed to minimize damage to the ground surface. If the surface organic layer is broken up or disturbed, serious environmental damage can result. On slopes the organic layer and its network of plant roots combine very effectively to resist water erosion. On permafrost areas this protective cover does more. It limits the degree of summer thawing in the "active layer", prevents the underlying permafrost from melting, preserves the stability of the terrain, and guards against a variety of hazardous erosion processes.

The development of the gas pipeline and its associated facilities necessitates the clearing of a number of areas, principally the 120-foot-wide right-of-way, which altogether totals some 32 square miles. Although timber will be felled and wildlife habitat lost within this area, it will be shown below that neither needs be environmentally damaging provided certain specified precautions are taken.

The more serious concern stems from the proposed clearing procedures—not so much from the techniques themselves, for these generally resemble those that are authorized in Land Use Permits issued under the Territorial Land Use Regulations and which are currently being applied in the two Territories—but rather from the scheduling of the clearing operations and in their specific applications. Clearing of the right-of-way a year ahead of construction and the removal of tree stumps from the line where the ditch is to be excavated will leave a disturbed surface exposed to a spring thaw and summer melt. Terrain subsidence, slope instability and stream siltation could all result. In the following sections the Assessment Group critically discusses the hazards associated with the various proposals and identifies precautionary measures that it considers would reduce or avoid risks.

Applicant's Proposals

The areas to be cleared are described in Sections 13.a.6.2 and 13.a.6.3. The Applicant proposes that these areas be machine cleared using bulldozers (Sects. 13.a.6.3; 14.d.N.5.3.1) and that machine clearing be supplemented or replaced by hand clearing where required (Sects. 13.a.6.3; 14.d.N.5.3.1). The vegetation will not be cleared from all areas at the same time but in sections, fitting in with the needs within each construction spread into which the over-all route is divided.

Initial clearing will be that required for control and location surveys (Sects. 13.a.6.2; 13.a.2.3.1, Figure 1)—usually long, narrow lines, isolated helipads, etc. For these clearing operations, disposal of the felled trees, slash and brush and subsequent clean-up will be delayed until the later clearing of the mainline right-of-way.

During the clearing of the mainline right-of-way any felled merchantable timber—principally white spruce and jack pine (Rowe, 1972)—will be cut and stacked for later use by either the Applicant or others. Non-merchantable timber, slash and brush

will be piled and burned, but piling methods are not described. In areas of sensitive permafrost, burning will be confined either to the 12- to 15-foot width of the right-of-way that will be subsequently excavated during the ditching operation (the ditchline) or to specially constructed incinerator sleighs (burning sleighs). After the pipe has been placed, burned residue and stumps will be buried on the spoil bank side of the ditchline at selected places along the right-of-way or in abandoned borrow pits (Sects. 13.a.6.3; 14.d.N.5.3.1). The clearing required for support facilities (wharves, stockpile sites, etc.) will probably proceed throughout the year utilizing both hand and machine methods (Sect. 13.a.2.3.1, Figures 2-10).

The major clearing operation is for the mainline right-of-way and is scheduled for the winter preceding the installation of the pipeline (Sect. 13.a.2.3.1, Figures 2-10). This will be primarily a machine-clearing operation, but supplemented by hand clearing where frost penetration has not been sufficient to support heavy equipment, or where machine clearing could harm the environment (Sect. 13.a.6.2). Where special Arctic construction techniques are required, tree stumps will be removed (grubbing) only from the ditchline, thereby limiting surface disturbance but at the same time facilitating the ditching operation (Sect. 14.d.N. 5.3.1). For areas of conventional winter construction, grubbing is not mentioned although the grading of the right-of-way will probably necessitate stump removal. In neither construction mode is the stump removal and piling technique described.

The Applicant considers the major river-crossings separately and describes their construction schedules in Sections 13.a.2.3.1, Figures 2, 4, 6, and 8. Slope preparation—which includes clearing—will be conducted the winter preceding installation, but in areas of sensitive permafrost it may be delayed to just before installation (Sect. 13.a.6.5.11).

Concerns

Clearing Operations

The proposed clearing and disposal methods, except for the burning sleighs and the special cutting attachments on the bulldozer blades, are as currently applied in the two territories. However. the following problems could result if the clearing techniques were inappropriately or improperly applied:

In high-ice-content soils, removal of the tree cover may result in the melting of the normally stable permafrost, causing subsidence or collapse of the terrain. This can occur even without disturbance of the organic mat (Linell, 1974). Although not expected to occur along the entire right-of-way, this danger is a greater possibility where a forest cover is underlain by high-ice-content soils.

A more serious danger is subsidence on slopes, leading to instability and slumping, as has been experienced on part of the Mackenzie Highway. Such slumping may result in stream siltation, through the mechanical transport of materials into streams, through thaw-flow slides, or through the hydraulic erosion of exposed soils. Siltation can be detrimental to fish population (*see* topic "Suspended Sediments") and may kill the vegetation at the base of slopes.

In high-ice permafrost areas the chances of such slope failure could be substantially reduced by shortening as much as possible the time between clearing and the implementation of slope stabilization measures.

The removal of tree stumps from the right-of-way

at the same time as the clearing operation—but separated by a year or more from the terrain stabilization procedures—leaves the ground surface highly susceptible to disturbance and erosion during both a spring melt and a summer thaw season. Effects could be alteration of the thermal regime in permafrost areas, hydraulic erosion with possible stream siltation, and slope instability.

In sensitive permafrost areas the consequences of stump removal are broadly similar to those of tree removal but are potentially more rapid, more severe, and wider ranging. Environmental effects would be most severe if conventional winter construction techniques were inadvertently applied to areas of sensitive permafrost (*see* topic "Arctic and Conventional Construction Procedures").

As in the case of clearing, the potential for erosion or slope failure as a consequence of stump removal is substantially reduced by shortening as much as possible the time between grubbing and pipe laying, and particularly by avoiding spring melt and summer thaw periods.

Preparation of the approaches to major river crossings could result in slope instability, erosion and siltation. The clearing of vegetation and the grading of riverbanks, if done the winter before pipe installation, would leave exposed to a spring melt a surface susceptible to erosion. The Applicant's schedules (Sect. 13.a.2.3.1, Figures 2, 4 and 9) indicate that, with the exception of the Mackenzie and Peel River crossings of the Prudhoe Bay lateral, some approach preparation will be undertaken the winter before pipe installation. On steep slopes involving unstable or ice-rich materials, temporary erosion-control measures could reduce the potential for disturbance between clearing and pipe installation.

Some surface disturbance is expected from machine-clearing operations in permafrost areas. While the Applicant suggests that such disturbance will be within predictable limits (Sect. 8.b.1.3.5.2), operator inexperience could result in unacceptable levels of disturbance and this could be aggravated in areas of small-scale permafrost earth mounds. Such disturbance could, of course, be avoided by "high-blading", in which the bulldozer blade is held above the ground. Experience has shown that simply equipping the blade with mushroom shoes will not overcome this problem.

Permafrost degradation may also result from the burning of slash and felled trees on the right-of-way (Inglis, 1974). While the Applicant does indicate (Sect. 14.d.N.6.3.2) that burning will be confined to the ditchline the fire may scorch and destroy the surrounding vegetation and its underlying humus mat.

The Applicant indicates that the clean-up and disposal of trees, slash, and brush following clearing for control and location surveys will be the responsibility of the mainline clearing crews a year or so later. This may not be satisfactory to Federal regulatory agencies. Freshly cut trees and slash are prime breeding materials for destructive bark-beetles and wood borers (Anon., 1974) and delays in disposal could result in the infestation of adjacent standing trees.

Merchantable-Timber Fellings

The forested areas crossing by the proposed pipeline route include Forest Section B18b, Hay River; B23a, Upper Mackenzie; and B23b, Lower Mackenzie (Rowe, 1972). In addition, there is non-forested tundra. The acreages affected (Sect. 13.a.2.2) total:

Forest Section	Acres
B18b	893
B23a	8052
B23b	3106
Non-forested tundra	3597

The areas affected within B23a and B23b add up to 11,158 acres or approximately 25 square miles. This represents 0.08 per cent of the total forested area (30,280 square miles) of these two Forest Sections (Canadian Forestry Service, unpublished data).

The volume of merchantable timber to be felled and its significance are difficult to estimate. Northern forests are patchy, difficult of access for harvesting and generally of slow growth (Anon., 1974). Productivity, for example, is around 7-8 cu ft/acre/yr compared with figures of 20 and 50 cu ft/acre/yr for Newfoundland and coastal British Columbia respectively. Nevertheless, stands of merchantable timber used by local communities may coincide with the pipeline right-of-way or facilities. The Applicant's proposal to make available to these communities only the timber in excess of his own requirements may not be satisfactory. It would be more satisfactory for communities if such stands were identified and an attempt made to avoid them. If merchantable timber were felled, local use could be facilitated by offering "first refusal" to communities and by transporting it to locations easily accessible to them.

Habitat Loss

Clearing operations will result in the loss or alteration of some wildlife habitats. Such changes may have local significance but the precise impact is difficult to assess. The major effects on fish populations are expected to be from siltation caused by uncontrolled erosion. Changes in water temperature occurring from the loss of shading by stream-bank vegetation are expected to be minor, as pipeline crossings are generally at right angles to streams and clearing will be minimal.

Rare and Endangered Plant Species

There are no known rare or endangered plant species or assemblages threatened by clearing operations. Although the Prime Route does pass through some proposed International Biological Programme areas, most notably the proposed Firth River Reserve, clearing requirements here are minimal.

Highlights

1. Carelessness in clearing the right-of-way, especially in permafrost areas and on river banks, can precipitate problems of long-term consequences, including erosion, slope failure and stream siltation, that could jeopardize the integrity of the pipeline, and in turn, harm other environmental characteristics. The most serious of these, however, can be prevented by the prudent scheduling and conscientious monitoring of clearing techniques.

2. Machine clearing in hummocky areas underlain by sensitive permafrost could lead to scalping of the surface and melting of the permafrost. Scalping could be avoided by the bulldozer operator using "high blading" techniques.

3. Clearing of the right-of-way a year or more in advance of terrain stabilization (which would follow pipe laying) on sloping ground, and particularly on river banks and valley walls in sensitive permafrost areas, raises concerns over potential slope failure, erosion, and siltation of waterbodies. These hazards would be decreased if:

(i) clearing and grubbing on slopes, particularly adjacent to river crossings and in

areas of sensitive permafrost, were delayed until the shortest possible time before pipe laying;

(ii) the essential "advance" clearing were done by hand;

(iii) temporary stabilization or erosion-control measures were applied where "advance" clearing and related activities on sensitive slopes result in any substantial disturbance of the ground surface.

. Delay in burning vegetation after clearing :reates environmental hazards. Where immediate ıurning is not practical environmental hazards :ould be reduced by topping, scattering, and win-lrowing felled trees.

ı. Small stands of merchantable timber are valu-.ble for future local use, particularly in commu-ıities. Community interests would be served by dentifying and avoiding such stands, by granting .o communities first refusal on any merchantable :imber that is felled, and by transporting any :imber requested by communities to locations cceptable to them.

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8.7 RIVER CROSSINGS

Introduction

Rivers are the most dynamic elements of the terrain that the proposed pipeline must cross. Processes in river channels vary widely in type and intensity in response to the climatic factors of temperature and water supply. Processes on individual rivers are locally conditioned by variations in slope, bed and bank material, sediment supply, water velocity, and water depth. In cold regions, deeply thawed zones in permeable materials beneath river channels can provide pathways for significant perennial flow of groundwater. In addition, many rivers provide critically important habitat and migration routes for fish, one of the most important biological resources in the Mackenzie Valley transportation corridor. Due to their very nature, rivers have the ability to transfer the consequences of environmental disturbance rapidly over great distances.

The above factors combine to make rivers among the more sensitive of terrain elements that will be subjected to disturbance by pipeline-related activities. Not only is the environment here particularly susceptible to disruption, but the potential for rapid change, both natural and induced, constitutes one of the greatest threats to the integrity of the pipeline itself. The complexity and dynamic attributes of rivers locally lead to a requirement for relatively complex, time-consuming, and costly construction techniques.

River crossings are classified, both in the Application and in this discussion, as "major" or "minor", depending on the construction technique required to cross it with a pipeline. A "major" river is one characterized by significant winter flow. Construction is best accomplished during periods of no ice. Separate designs and construction methods are proposed for each crossing. "Minor" rivers, on the other hand, are those that are characterized by little or no winter flow in the channel. The river is frozen to the bed, or nearly so, in winter. Construction is proposed during the winter by the regular pipeline crew using basically the same techniques that are used on land.

Applicant's Data

The Applicant has identified six river crossings as "major": the Peel, Great Bear, and Liard rivers and the Mackenzie River near Swimming Point, Point Separation, and Burnt Island. Preliminary designs for these are presented (Sect. 8.b.3) as drawings 1E-0210-1001, 1B-0210-1007, 1B-0210-1018, 1A-0210-1001, 1E-0210-1003 and 1B-0210-1017, respectively.

The Applicant describes (Sect. 13.a.6.5.11) the procedures and schedules proposed for major crossings. In summary these are:

(a) January to March: preparation of banks and any drilling and blasting required for a trench across the river bed;

(b) May to August: preparation of pipe and assembly of pipe string on one of the river banks;

(c) July to September: excavation of a trench across the river bed using combinations of back hoes, clam shells, draglines, or dredges, the spoil to be cast downstream; and

(d) August to October: winching of the artificially floated pipe string across the channel and final inspection of pipe before lowering of the pipe into the trench and back-filling of the trench with excavated spoil or other material;

ackfilling of the bank approach trenches, and ap-ropriate erosion control and slope stabilization.

ocal conditions may require the following local odifications of the above process:

a) Where sensitive permafrost is present, pre-aration of the bank approaches may be delayed un-il the early fall, immediately prior to the cross-ng operation. Alternatively, slope stabilization easures may be advanced to the summer months; and

b) Where there are steep side slopes, or shal-ows on one side of the river, the pipe prefabri-ation area may be located on barges or on a berm. berm would be constructed with material excavat-d from the channel trench, from the approach lopes or, if necessary, from borrow pits. It ould extend approximately one third the distance cross the river and be of sufficient width—ap-roximately 80 feet—to accommodate three pipe trings. One of the pipe strings would be lowered into a trench excavated in the berm itself. The erm would then be removed and the granular mate-ial used for backfill or for erosion control. The Applicant has proposed barges or berms for use t the crossings of the Liard River, the Great Bear River and the Mackenzie River near Swimming Point. Either of these procedures would delay the preparation of the pipe prefabrication area until after the spring flood.

Preliminary designs are shown for the Firth River crossing in drawing 1C-0210-1001 and for four other "minor" river crossing types in drawing 4-0210-1099 (Sect. 8.b.3). Cut grading of the banks at minor crossings would be limited to the amount required to provide for placement of the slope section and the sag bends in the banks. Where necessary, slope stabilization and erosion-control programs would be implemented (Sect. 8.b.1.3). The trench would be excavated through the ice, if necessary, using a combination of drilling and blasting, clamming, hoeing, dredging and draglining as dictated by the nature of the bed material. The pipe would be lowered into the trench with side boom tractors and cranes or, if the channel were too wide or too deep, by the bottom pull method described for major crossings.

Depth of pipe burial beneath river channels where the river bed is easily erodible will not be less than five feet (Sect. 14.d.N.7.3). For large riv-ers, the depth of burial is based on best esti-mates of potential scour, determined either from maximum discharge or ice jamming records and existing scour holes. Depth of burial has then been computed to prevent exposure of the pipeline under what are judged to be the worst scour con-ditions. In bedrock, the pipe will be buried one foot below the bedrock surface, unless studies prior to final design indicate that the bedrock is particularly erodible, in which case burial will be carried to the maximum estimated scour depth.

The Applicant states (Sect. 14.d.N.3.3) that data have been collected on the potential for ice jam-ming or ice scour at major river crossings, that spring break-up and ice movements were observed and that soundings were made through the ice to determine water depth, ice thickness and presence of slush ice. This type of field investigation, if continued as indicated in Section 8.b.1.3.8.3.1, should provide information that is important for final design purposes.

Estimates of maximum water levels and river-regime principles have been used in estimating bed scour and in delineating areas outside the normal chan-nel where scour will occur and pipe weighting will be necessary. Those water levels used for the designs accompanying the Application (primarily major crossings) were based on flood studies, field investigations of high water marks, field investi-gations of ice jams, and references to the liter-ature (Sect. 8.b.1.3.8.3.2).

The Applicant states that in analyzing a river reach for potential lateral migration of the channel, channel bank positions as indicated on 20-year-old and new aerial photographs were compared (Sect. 8.b.1.3.8.3.3.5). Furthermore, it is stated that if crossings are made at points where the banks are particularly subject to erosion, the reach of the bank which could ultimately affect the pipeline will be protected by bank armouring (Sect. 14.d.N.7.3). This is exemplified in the preliminary design drawing for the Firth River crossing (1C-0210-1001 in Sect. 8.b.3) where a 25-foot bank with a slope of 1 in 2 is shown reduced to a finished grade of 1 in 5 with as much as 20 feet of selected backfill covering the native material.

Concerns

There is a broad range of concerns regarding proposed river crossings. Some concerns focus on the potential for construction and operation to initiate direct consequences for the environment, and some focus on factors that threaten the pipeline itself, with indirect consequences for the environment. All of them ultimately relate to terrain stability, aesthetics, and/or fish resources. That the concerns are expressed in somewhat general terms is due to the Applicant not having provided a specific rationale for design concepts applied to river crossings. This general deficiency has been the subject of three specific requests in the "Requests for Supplementary Information" (#35, 36, 37). Detailed information on the types of data used, how they are obtained, and the manner in which they have been or will be applied to the determination of precise crossing locations and to selection of design specifications would be of interest.

The principal concerns, treated separately in more detail below, involve sediment movement, dispersal of toxic substances, channel constriction, icings, local bed scour, general degradation of the bed, lateral migration of the channel, channelization, and stability of the bank approaches.

Sediment Movement

Construction activities at river crossings that are carrying any channel flow at the time will temporarily increase the suspended sediment concentration. The potential for adverse effects on the aquatic habitat downstream is largely a function of the amount of this increase, the length of time it is sustained, the time of year, and the tolerance limits of aquatic biota. The Applicant's comparisons of the magnitude of the increase to the natural concentration of suspended sediment at any given time (Sect. 14.d.N.7.3) are not necessarily meaningful because the biologic elements are adapted to the natural sediment cycle and because any major disturbance of this cycle may increase mortalities. Reference to other examples of the effects of construction on suspended sediment concentrations (Sect. 14.d.N.7.7.1) is also of limited value unless construction techniques and bed material are known to be comparable and unless biologic repercussions in the example have been carefully monitored. Many rivers in the Mackenzie Valley carry large suspended sediment loads that are subject to great variations in concentration. On such rivers the effects of construction on suspended sediment concentrations would likely be less important than on clear rivers such as the Great Bear River with its important fish population.

Discharges at major crossings are high enough to carry the increased sediment load a long way downstream. Silt deposits on the bed would probably be negligible, except perhaps in the biologically productive back eddies. The Applicant has noted (Sect. 14.d.N.7.7.1) that in minor streams, where the winter capacity for sediment transportation is limited, relatively rapid deposition of suspended

sediment downstream of the crossing would be expected. This could seriously affect overwintering fish and local benthic organisms in the vicinity. Most of this sediment would likely be flushed out during the succeeding spring run-off.

The trenching method, disposal of the spoil (cast downstream, upstream or stored on the bank), the nature of the river-bed material, and discharge can all influence the concentration of sediment carried downstream in suspension. These are subject to some degree of control in selection of the crossing site, timing, and installation of the pipe.

Subsequent to construction, sedimentation resulting from the pipeline would be limited to that caused by bank failures and erosion from approach slopes. The amount would depend on the efficacy of the proposed slope-stabilization and erosion-control measures (Sect. 8.b.1.3).

A break in the pipe at the river crossing could result in severe sedimentation problems if the urgency of repair operations required massive movements of men and machinery without an opportunity to optimize timing of the operation.

Dispersal of Toxic Substances

Other pollutants, in addition to suspended sediment discussed above, may enter the river system during construction activities at the crossing. The time of release of these into the river would depend on construction schedules. Potential pollutants include lubricants and fuels used for construction at the site, warm water or a water-methanol solution used for testing the pipe performance, and natural gas escaping from a pipeline leak or rupture beneath the river. Normally the gas would rise to the surface and escape into the air, with only a small amount going into solution. However, gas could be dissolved in the water in winter where the river flowed beneath a thick solid ice cover.

As with suspended sediment, the above-named pollutants could pose a threat to the aquatic ecosystem if released in concentrations above certain critical levels. Tolerance limits of local biologic elements would have to be considered in assessment of the local risk.

Channel Constriction

A number of proposed construction practices will temporarily result in constriction of the cross-sectional flow area in the channel, leading to locally increased flow velocities. These higher velocities are of concern in view of the increased potential for scour of the river bed and bank, and in view of the possible inability of the aquatic fauna to cope with the velocities. Higher velocities could interfere with fish migration by delaying the fish too long at a constriction.

Practices that could temporarily constrict the channel include:

at major crossings: construction of berms or coffer dams part way across the channel and sinking of barges; and

at minor crossings: disposal of spoil from the trench onto the river bed in the already restricted flow cross-section.

Icings

Numerous natural river icings occur in the northern part of the area traversed by the proposed pipeline route, particularly in the northern Yukon and below the western slopes of the Norman and McConnell ranges. They commonly take the form of extensive tabular bodies of ice on the active river plain. They mark locations where water, usually groundwater, has emerged at the frozen surface in winter and spread out downstream before being frozen as a sheet of ice on top of the river plain. Groundwater flow persists beneath the

river channel after the surface has frozen in the autumn. When the advancing seasonal frost locally cuts off this flow by reaching a relatively impermeable boundary, hydrostatic pressure develops upstream and water may break through onto the surface. Such icings normally start forming early in winter; in many cases development stops before midwinter, either because no further water is available beneath the channel or because outlets freeze over. Icings may accumulate to thicknesses of many feet. They persist during spring run-off and commonly deflect the water around them. During the summer, icings melt back, but some are so massive that they persist throughout the year. Icings tend to be located in the same place year after year, a reflection of the interaction between autumn freeze-back and the relatively permanent groundwater flow boundaries beneath the channel. Carlson and Kane (1973) have presented data for Goldstream creek near Fairbanks, Alaska, which show that the level attained by the top of the icing reflects the piezometer head in the unfrozen zone between the permafrost and the encroaching seasonal frost, and that both may exceed the level of the top of the banks and the adjacent land.

Other general subjects of icings are discussed also in the topics "Springs and Icings" and "Chilled Pipeline".

It is evident from the above discussion of natural river icings that pipeline construction and operation activities may induce local new icings in the following ways at minor river crossings:

(i) trenching operations in a frozen river channel may breach or weaken the frozen carapace sufficiently that groundwater under hydrostatic pressure could be released upward, flooding the trench and spreading out over the surface; and

(ii) during operation, chilled gas in the pipe may foster the development of a relatively impermeable frost bulb around the pipe large enough to restrict groundwater flow, and force the water to the surface where it would freeze in winter and form an icing.

The Assessment Group is concerned that, in addition to posing construction and maintenance problems, such initiation of new icings might have the following consequences for the environment:

(i) depletion of winter water supply to important fish overwintering areas downstream; and

(ii) lateral deflection of the spring run-off, resulting in intensified erosion of the river bank, accelerated lateral migration of the channel, and contribution of large amounts of suspended sediment to the river.

Detailed groundwater and geothermal studies at river-crossing sites would be required to assess the probability and severity of potential icings at minor river crossings. Where the potential for severe icings was identified, consideration could be given to alternative crossing sites or to the use of different modes of construction or operation.

Local Bed Scour

Methods of estimating depth of bed scour, particularly in ungauged gravel-bed Arctic rivers, are rather primitive and tend to be empirical. Among the factors that must be considered are a suitable design discharge (related to local design flow conditions), incidence of hydraulic or ice scour associated with ice jams, channel slope, and the size, irregularity, type of packing, and degree of cohesion of bed material.

As a basis for design, the Applicant has presented a figure (Sect. 14.d.N.4.3-2) that shows the maximum recorded discharges of all gauged streams in

the Yukon and Northwest Territories, plotted against the drainage areas. The highest recorded values are enveloped by a curve which assumes that flood discharges increase as the square root of the drainage area. However, the discharge records used for the envelope curve are of short duration and biased towards large rivers with lake storage. With few exceptions the gauging stations have been in operation only since the 1960's. There is some evidence that the Applicant does not use the proposed envelope curve for design purposes. For example, the design flood used for the Firth River crossing (Sect. 8.b.3) is 26,000 cu ft/sec, a value that is only 34 per cent of that derived from the proposed envelope curve. Furthermore, the design flood used is only 120 per cent of the maximum instantaneous peak that has been observed since a gauging station was installed on the Firth River in June, 1972. Even the envelope curve provides estimates of maximum flood discharges that are only 72 per cent of the maximum known flood on the Liard River; 56 per cent of the mean annual 100-year flood for the Peel River estimated by Thakur and Lindeijer (1973); and 86 per cent, 54 per cent and 45 per cent of the July 22, 1970 flood on the Keele, Mountain and Arctic Red rivers, respectively, as computed from slope-area surveys by MacKay *et al.* (1973). Burns (1974) estimated that the maximum four-day rainfall for the storm that produced the latter flood exceeded five inches and that the return period is between seven and 16 years. Although it could be argued that storms of this magnitude are peculiar to mountainous terrain, Burns presents a table which indicates that, for nine stations along the Mackenzie River, the annual maximum 24-hour precipitation with a return period of 20 years has an average value of two inches. These data indicate that a more conservative design curve may be more appropriate.

Bed scour resulting from concentration of flow beneath ice jams adds considerable uncertainty to the design of major river crossings; variation in timing, location, and intensity of ice jams from year to year precludes definitive assessment of scour potential. The best approach to estimation of such scour would be a conservative one, based on all available data.

Resistance to scour depends on the nature of the bed materials. It is usually possible to get a good estimate of grain-size distribution, but other qualities such as grain shape, type of packing, or degree of cohesion are more difficult to evaluate. Furthermore, there is a sampling problem in assessing the variation in the nature of the bed material from point to point in the cross-section. The Applicant has presented the results of a number of test holes at river crossings on the preliminary design drawings of Section 8.b.3. However, most of these are on the approach slopes, with only a few in the flood plains and none in the low-water channels. The preliminary design drawings presented by the Applicant are based on cross-sections at the proposed crossing sites in most cases. However, the cross-section for the Liard River is from a location 5,300 feet downstream from the proposed crossing site.

The foregoing considerations indicate that, while deep scour is more likely to occur at major crossings than at minor ones, estimates of scour depth tend to be crude at best. In the project area, where the environmental costs of repairing pipeline breaks at river crossings will be great, there is every incentive to use a high factor of safety in deciding on a safe depth of pipe burial beneath the rivers.

General Degradation of the Bed

More general lowering of the river bed over an entire reach of the river may supplement the effects of local bed scour. General bed degradation occurs naturally when the river slope or velocity is increased or when an event upstream decreases

the sediment load being delivered to a particular reach. Pipeline-related activities that cause the removal of bed or bank material either upstream or downstream from the crossing site may result in a general lowering of the river bed over the pipe. This could locally be an important design factor leading to a need for increased initial depth of pipe burial.

Lateral Migration of the Channel

Lateral migration of the river channel can expose or wash out the pipe that lies beyond the sag bends, where burial depths have not been designed for bed scour. Lateral migration is usually initiated during floods when fast water impinges on a high-water bank at a point with low resistance to erosion.

McDonald and Lewis (1973) suggested that rivers of the Yukon Coastal Plain commonly have banks that are less stable than the channel beds. The beds are usually wide, composed of coarse gravels, and accommodate increasing discharges by increases in river width rather than by large increases in river depth. The banks are usually low and composed of relatively fine-grained flood-plain sediments (often underlain by relic gravel bars). The banks are particularly susceptible to slumps resulting either from the melting of segregated ice by flood waters (thermal niching), or from the removal of vegetation by floods and the subsequent melting of ground ice. The relative stability of the bed material causes much of the erosive power of the river to be concentrated on the banks, thereby leading to rapid lateral migration of the high-water channel. A number of examples of lateral migration of low-water channels are shown by McDonald and Lewis (1973, p.50-55). There were few areas, however, where rapid lateral migration of entire channel zones was detected on air-photograph comparisons.

Comparisons of aerial photographs do not, of course, reflect the increased potential for lateral migration created by the pipeline itself. The two areas of concern are:

(i) bank slumping caused by the removal of vegetation and ditching, followed by melting of ground ice. This concern applies primarily to the period before the pipeline is activated and chilled. The increased potential for lateral migration depends on the efficacy of the slope stabilization, erosion control, revegetation and bank armouring procedures in addition to the nature of the floods during the vulnerable period.

(ii) deflection of the spring flood by an icing initiated at the pipeline crossing. The potential for lateral migration of the channel to "flank" the river crossing installation and expose the approaches to erosion warrant consideration and a high factor of safety in locating sag bends and in armouring steep banks.

Channelization

"Channelization" here refers to localities where new channels could develop in orientations that would be controlled to some extent by pipeline-related features. New channels could develop, for example, along a right-of-way that crossed a river channel obliquely, or on flood plains where vegetation along the right-of-way had been removed or where flow had been deflected by an icing. The Applicant has recognized this potential (Sect. 8.b.1.3.8.3.3.5), and has proposed solutions.

Stability of the Bank Approaches

Instability of steep bank approaches is one of the principal problems in the design of both major and minor crossings. In addition to the dangers to

pipeline integrity, it could cause significant sedimentation and aesthetic deterioration. Bank instability was discussed in connection with lateral migration. The discussion is pertinent to the instability of high banks when the instability is induced by the action of flood waters at the bases of the slopes. High, steep slopes can also become unstable because of the high pore pressures in the banks after recession of floods, and melting of ground ice and erosion at levels well above the highest flood. The Applicant has proposed (Sect. 8.b.3) a range of slope stabilization procedures that include flattening the bank and then armouring it with rock or wire mattress, and emplacement of stabilization berms at the crossing.

The consequences of bank instability at river crossings are sufficiently serious to require close attention during the final design stage.

Highlights

A river crossing focuses, at a single locality, on almost the entire range of concerns surrounding terrain instability, aesthetics, and fish resources discussed along the pipeline route. Rivers are dynamic elements of the terrain and vital elements in the aquatic ecosystem. Major concerns over the Applicant's proposals for river crossings are highlighted below.

1. Insufficient detail has been provided regarding types of data used in the design rationale, how they are obtained and how applied, both to the design details and to selection of a crossing site, to relieve the many concerns of the Assessment Group over the environmental consequences of the construction and operating procedures proposed.

2. A number of concerns focus on the potential for pipeline construction and, to a lesser degree, pipeline operation, to initiate a variety of environmental effects:

- temporarily increased levels of suspended sediment in the river downstream and the possibility of locally covering the natural river bed with new sediment could adversely affect overwintering fish and benthic organisms in the vicinity;

- toxic substances used at the crossing during construction could, if allowed to escape into the river, pose a threat to the aquatic ecosystem for some distance downstream;

- temporary flow constrictions during construction will temporarily increase local flow velocities; consequences of this on terrain stability and on migrating fish populations warrant consideration; and

- initiation of new icings in the vicinity of the crossings could have serious consequences for environment and pipeline alike; detailed groundwater and geothermal data at the crossing site would assist in identification of this risk in time to consider either relocation of the route or use of a different construction or operation mode.

3. A number of concerns, while representing a direct threat to the pipeline itself, have also indirect consequences for the environment insofar as urgent repair of a damaged line may be required at times of ecosystem or terrain sensitivity:

- prediction of the intensity and distribution of local bed scour is a primitive art; factors that affect it, such as design flood, ice jams, and the scour resistance of the bed, are very difficult to evaluate with confidence; a very conservative safety factor may be a suitable response to this uncertainty;

- removal of material from the bed or banks of the

river both upstream and downstream of the proposed crossing site could result in general lowering of the river bed over the buried pipe;

- lateral migration of the river channel at the crossing site could expose the approach sections to erosion unless the migration is impeded by appropriate measures;

- concentration of river flow along the pipeline right-of-way could localize erosion over the pipe; and

- thermo-hydraulic erosion at the base of high river banks, and high pore pressures in bank sediments after recession of floods could result in a bank instability that would threaten the approach to the river crossing and possibly, by changing the flow pattern in the river, the crossing itself.

4. The threats posed to the environment at river crossings warrant further detailed consideration of such factors as location and method of disposal of spoil from the trench, effects of different excavation equipment, timing of the construction, depth of burial of the pipe beneath the river and under the approaches, and the groundwater and geothermal conditions in the vicinity of the crossing.

5. The present review of river crossings is limited by the preliminary nature of the Applicant's proposals, and site-specific comments are not attempted except in the general review of valleys (*see* topic "Pipeline Impact in Valleys"). The Assessment Group considers that a further review would be appropriate at the final design stage.

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8.8 PIPELINE IMPACT IN VALLEYS

Introduction

The valleys crossed by the pipeline route and the streams within them constitute only a small portion of the total landscape, but have disproportionately high land-use, environmental, aesthetic and recreational values. The streams comprise much of the fish spawning and rearing habitat, and aquatic mammal habitat of the region, and the valley floors comprise much of the prime moose wintering habitat. Whereas the upland area between valleys generally is flat to gently rolling, much of it with monotonous scrub black spruce forest, the valleys have varied vegetation and afford attractive vistas. This, together with the streams, fish and wildlife, give the valleys special recreational value. Valleys have been preferred travel routes for centuries and are relatively rich in historic and archaeological remains. Moreover, traplines follow along valleys, and campsites, fishing areas and communities are found in them.

The valleys and the rivers within them, at the same time, are unusually sensitive to environmental and aesthetic damage. Although sloping valley walls constitute only a small part of the land area of the regions, 75 per cent or more of natural slope failures (slides, mudflows, etc.) occur there; a high percentage of the slope-stability problems encountered during construction and operation of a pipeline will likewise be on valley walls. These slope failures, together with water erosion, can lead to siltation of the stream, with consequent deterioration of the aquatic environment.

Valley walls, especially the steeper ones, are significant obstacles to pipeline construction. The Applicant anticipates that even in permafrost areas, some grading and cutting of valley walls would be required to provide suitable gradients for safe operation of equipment and transport vehicles, and to keep bends in the pipe within stipulated limits; sloping surfaces, exposed by the grading and cutting will be particularly subject to slope instability and erosion. Valleys will present obstacles to movement of maintenance equipment as well, particularly if a pipeline break necessitates overland movement of heavy equipment in summer months when vegetation and terrain are particularly sensitive to damage.

In view of their special values and high vulnerability, valleys and the streams within them deserve particular consideration in all phases of the pipeline project, from location and design through construction, operation, maintenance and abandonment. The tabular listing of concerns for all the larger valley crossings along the Applicant's proposed route provides a basis for identifying those of high sensitivity to the pipeline development.

Applicant's Data

The Applicant has provided only a brief statement relating specifically to valley walls and stream approaches:

> Many of the steeper slopes along the pipeline route occur on the approaches to river crossings. In order to maintain the integrity of the pipeline and to minimize environmental disturbance, it is of particular importance at these locations to assess the slope stability and to design any necessary stabilization measures. The drainage and erosion control requirements, which include the proposed revegetation techniques, must also be carefully designed. These topics are discussed in detail elsewhere in this section. (Sect. 8.b.1.3.8.3.4)

However, the extensive data provided on slope

stability and erosion, on slope stabilization and erosion-control measures (including revegetation) and on rivers are relevant to this review of valleys.

Concerns

Many of the concerns relating to pipeline impact in valleys are special cases of subjects dealt with in other topic sections of this report. The sensitive components include terrain and hydrology, slope stability and erosion, aesthetics, fish and aquatic habitat, mammals and birds, archaeological sites, fishing sites and other aspects of traditional activities, recreation sites, and other land use. The nature and intensity of impacts will be influenced by the design, by construction methods, by rehabilitation, stabilization, and revegetation measures, by maintenance and repair procedures, as well as by location.

Choice of location of pipeline crossings in valleys involves a rating of local biological, land-use, terrain and river components. In terms of terrain and river character, a crossing ideally should be located where valley walls are low, gently sloping and (in permafrost areas) where soils are stable on thawing. The stream within the valley should be crossed at a point where there is minimal likelihood of shifting of the channel. Crossings should be avoided at points where the stream impinges against the toe of the valley wall, and preferably there should be a width of low terrace between each valley wall and the stream. Then, if despite erosion-control and slope-stabilization measures, either erosion or slope failures develop, silt will not be introduced directly into the stream, and space will be available for constructions of brush dams or other devices to contain the silt (*see* Figure). Finally, locations of crossings close to the proposed Mackenzie Highway (where applicable) would reduce concern about terrain damage in movement of heavy equipment across sensitive valley terrain for repair or maintenance operations.

Sensitivity Table

The table identifies estimated sensitivity factors for most of the valley crossings along the Applicant's proposed route and also for some wharf sites along the Mackenzie. Many subjective decisions have been involved in preparing this table, and not uncommonly based on incomplete data.

Therefore the table must be viewed as an approximation, and used for general comparisons rather than as a source of specific information. The terrain and hydrology rating of high (XX), medium (X) and low (no symbol) is a generalization of individual ratings of a number of parameters of the valley and the river. For other factors an 'X' indicates that there is some level of concern, with no attempt at rating. Thus the sum of 'X's' indicates breadth rather than magnitude of concern, but nevertheless provides a rough measure of the relative concern at respective valley crossings. The level of concern is increased for crossings involving pipeline facilities as recorded in the third column. The facilities, including borrow pits and interconnecting roads, present considerable potential for siltation and pollution. Large unvegetated areas (more than 40 acres for a 6,000-foot airstrip, up to 200 acres for a borrow pit) will be subject to sheet run-off during heavy rains. Large quantities of fuel will be stored and handled at wharves, stockpile and compressor sites and airstrips. Large quantities of liquid and solid wastes will be produced at sites that serve as construction camps.

A high potential for pipeline impact is evident for the crossings of the East Channel of Mackenzie River, and the valleys of Thunder River, Loon

River, Hare Indian River, Oscar Creek, Vermilion Creek, Great Bear River, Saline River, River between Two Mountains, and Willowlake River. It is evident from the table that a number of others have a substantial potential for impact.

The Thunder River crossing is illustrative of high potential impact, as identified in the table. Thunder River valley is deeply incised into thick ice-rich glacial deposits and weak shale bedrock; the steep valley walls are therefore judged to be potentially unstable. The valley floor is narrow, so that with slope failure or gully erosion silt would be introduced directly into the stream with no opportunity for containment measures. Terrain sensitivity is therefore rated as high. A fish concern is identified on the basis of fish spawning and rearing areas below the pipeline crossing. The valley is a traditional trapping area and travel route, with concern noted under "other uses by people". From the headwaters of the river, a chain of lakes leads through a picturesque valley to the headwaters of Anderson River, affording a potential wilderness canoe route from Mackenzie River to the Arctic Ocean. The pipeline crossing, together with the compressor site at the top of the valley wall would detract from the wilderness aspect, hence a concern is registered under "Recreation/Aesthetics". The compressor site is located astride the confluent drainage from three small lakes; disruption of the drainage could induce gullying on the valley wall and stream siltation. A 6,000-foot airstrip is located parallel to and immediately adjacent to a tributary of the river; run-off from the airstrip could contribute to siltation of the lower reaches of the stream. At the prime borrow site, a thin layer of sand and gravel may be underlain by sensitive ice-rich silt and clay. Borrow pit operations could result in aesthetic damage and siltation. (*see also* "Construction of Pipeline Facilities and Roads") The level of terrain sensitivity at Thunder River could be reduced by relocating the crossing upstream near the Mackenzie Highway where valley slopes are lower and less steep, and where on the south side at least, there are relatively thaw-stable sand and gravel deposits. Relocation of the compressor site to a better drained area a mile of so from the valley wall would reduce concern regarding interruption of drainage, gully erosion on the valley wall, and obtrusion on wilderness scenery along the valley. Additionally, location of the site so that surface drainage leads to a pond not critical to fish or wildlife would provide an opportunity for secondary control of fuel or sewage spills or of siltation by run-off from the camp area.

Great Bear River at the proposed crossing is incised into ice-rich clay overlain by sand and the river impinges against the toe of the steep south wall of the valley. Under such conditions, there is high potential for shallow, deep-seated or retrogressive thaw failures (arcuate scars near the top of the valley wall 2,000 feet upstream from the crossing indicate an old deep-seated failure). Relocation of the crossing 3,500 feet upstream of the proposed one would permit descent of the south wall where a broad terrace protects the toe of the slope and provides a potential containment area for control of siltation; a narrower terrace provides a limited containment area on the north side.

Highlights

1. Valleys have particular environmental, land-use, and recreation/aesthetic values and are more sensitive to disturbance as a consequence of pipeline development than many other parts of the pipeline route. The Assessment Group considers it important that special measures be taken to reduce negative impacts in valleys at all stages of pipeline development.

2. In physical terms, valleys preferably are crossed where valley walls are lowest, least steep, and most stable and where low terraces bordering the river provide containment for waste and debris.

3. Pipeline facilities and borrow pits in valleys may considerably increase potential for disturbance.

4. The accompanying table lists sensitivity estimates for most valleys along the proposed route and provides a basis for identifying crossings of high sensitivity to pipeline development. The Thunder River crossing is illustrated as an example of high sensitivity.

5. In addition to the Thunder River, the East Channel of Mackenzie River, Loon River, Hare Indian River, Oscar Creek, Vermilion Creek, Great Bear River, Saline River, River Between Two Mountains, and Willowlake River are identified as displaying high potential for pipeline impact. A number of others display a substantial potential for impact.

6. Crossing sites with apparent lower sensitivity are identified for Thunder River and Great Bear River.

VALLEY AND RIVER SENSITIVITY TABLE

Mileage[1]	Crossing	Associated[2] Facilities	Terrain & River[3] Sensitivity	Fish[4]	Birds & Mammals[5]	Fishing Area[5]	Other Use[5] By People	Recreation/[5] Aesthetics	Archaeology
.5				X	X	X			
.8	Harry Channel			X	X	X			
1.3									
3.1									
19.8				X		X			
{23.9 RMP 1042	Mackenzie R East Channel	W S	X	X		X	X		X
29.4	Holmes Cr		X	X					
89.2									
92.5									
142.1	Rengleng R	P	X						X
127.3	Rengleng R								X
165.6	Travaillant R		X				X		
173.4	Thunder R North Trib		X						
177	Thunder R	C S A P	XX	X			X	X	X
RMP 802	Mackenzie R	W	XX	X					X
179.4	Thunder R South Trib		X						
RMP 763	Mackenzie R	W S		X					
250	Tieda R	P	X	X	X		X		
RMP 710	Mackenzie R	W	XX	X		X			
269.2	Loon R		XX	X	X		X		
285.5	Hare Indian R		XX	X			X	X	X
RMP 685	Mackenzie R	W S	?	X		X	X	X	X
318.3	Donnelly R		X	X					X
336.8	Hanna R								X

Mileages: All river crossing locations are expressed as pipeline mileages
All wharf sites are expressed as river mile post (RMP) mileages

Associated Facilities: W - wharf; S - stockpile site; P - borrow pit; C - compressor station; A - airstrip

Terrain and River Sensitivity: XX - high sensitivity; X - moderate sensitivity; No Symbol - low sensitivity

Fish: All rivers have some fish concerns. Only those with a notable concern have been highlighted in this Table. X - notable concern; No Symbol - ordinary concern

Other Parameters: X - concern; No Symbol - no concern or low concern

VALLEY AND RIVER SENSITIVITY TABLE
(continued)

Mileage[1]	Crossing	Associated[2] Facilities	Terrain & River[3] Sensitivity	Fish[4]	Birds & Mammals[5]	Fishing Area[5]	Other Use[5] By People	Recreation/[5] Aesthetics	Archaeology
356.9	Oscar Cr.	P C S	X	X	X		X		X
RMP 584	Mackenzie R	W	XX	X		X	X		X
373.3	Bosworth Cr	P			X			X	
385.4	Canyon Cr		X				X		
388.7	Francis Cr	P							
389.3	Heleva Cr		X						
390	Christina Cr								
393.2	Prohibition Cr		X						
400.4	Vermilion Cr	C P	X	X	X			X	X
421	Great Bear R		XX	X		X	X		
RMP 512	Mackenzie R	W		X		X	X		X
455.4	Big Smith Cr						X		X
465.2	Little Smith Cr			X					
471.2			X						
478.7	Saline R	P	XX				X		X
487	Steep Cr		X				X		X
RMP 435	Mackenzie R	W		X					
504	Blackwater R Trib		XX				X		
508.1	Blackwater R	P	XX	X					
533.2		P	X						
RMP 384	Mackenzie R	W		X					
537.7			X	X	X				
542	Ochre R		XX	X					
553.6	Hodgson Cr			X			X		
565.6	Smith Cr	P	X	X			X		

[1]Mileages: All river crossing locations are expressed as pipeline mileages
All wharf sites are expressed as river mile post (RMP) mileages

[2]Associated Facilities: W - wharf; S - stockpile site; P - borrow pit; C - compressor station; A - airstrip

[3]Terrain & River Sensitivity: XX - high sensitivity; X - moderate sensitivity; No Symbol - low sensitivity

[4]Fish: All rivers have some fish concerns. Only those with a notable concern have been highlighted in this Table. X - notable concern; No Symbol - ordinary concern

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VALLEY AND RIVER SENSITIVITY TABLE
(continued)

Mileage[1]	Crossing	Associated[2] Facilities	Terrain & River[3] Sensitivity	Fish[4]	Birds & Mammals[5]	Fishing Area[5]	Other Use[5] By People	Recreation/[5] Aesthetics	Archaeology
582.6	River Between Two Mountains	P	X	X			X		X
RMP 334	Mackenzie R	W		X		X	X		X
599.6	Willowlake R		X	X		X	X	X	X
{643.7 RMP 255	Mackenzie R	W S	X	X					X
656.8		P	X						
680	Martin R	P		X	X		X		
700	Liard R		X						
745.2	Trout R			X					
807.7	Kakisa R	P C A		X					
PRUDHOE BAY LATERAL[6]									
194.8	Clarence R	P							
197.2	Craig Cr								
198.2		P							
203.9	Backhouse R								
211.2									
217.3	Fish Cr			X					
223.1	Malcolm R	P C		X	X				X
233.1	Firth R	P	X	X	X				X
255.1	Spring R	P	X						
265.9	Crow R								

[1]Mileages: All river crossing locations are expressed as pipeline mileages
All wharf sites are expressed as river mile post (RMP) mileages

[2]Associated Facilities: W - wharf; S - stockpile site; P - borrow pit; C - compressor station; A - airstrip

[3]Terrain & River Sensitivity: XX - high sensitivity; X - moderate sensitivity; No Symbol - low sensitivity

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[5]Other Parameters: X - concern; No Symbol - no concern or low concern

[6]Prudhoe Bay Lateral: There are caribou and waterfowl concerns on the Yukon section of this route but they are not specific to river valleys and are therefore not listed as river valley problems

VALLEY AND RIVER SENSITIVITY TABLE
(continued)

Mileage[1]	Crossing	Associated[2] Facilities	Terrain & River[3] Sensitivity	Fish[4]	Birds & Mammals[5]	Fishing Area[5]	Other Use[5] By People	Recreation/[5] Aesthetics	Archaeology
268.8	Trail R	P							
279.2	Babbage R		X	X					
291.2	Conglomerate Cr		X						
293.3	Deep R		X						
298.2	Walking R								
306.8	Blow R	P	X						
316.3	Rapid Cr	P	X	X					X
323.6			X						
331.6			XX						
338.4	Fish R	P	X	X		X			X
361	Beaverhouse Cr	C						X	X
RMP 1010	Mackenzie R	W		X		X			
375.8	Willow R	P							X
RMP 990	Mackenzie R	W		X		X			
407.5	Rat R	P C		X		X	X	X	X
419.2									
{431.5 RMP 950	Peel R	W S	X	X		X	X		
441.6	Frog Cr								
{457.5 RMP 902	Mackenzie R	W S P		X	X	X			

[1]Mileages: All river crossing locations are expressed as pipeline mileages
All wharf sites are expressed as river mile post (RMP) mileages

[2]Associated Facilities: W - wharf; S - stockpile site; P - borrow pit; C - compressor station; A - airstrip

[3]Terrain & River Sensitivity: XX - high sensitivity; X - moderate sensitivity; No Symbol - low sensitivity

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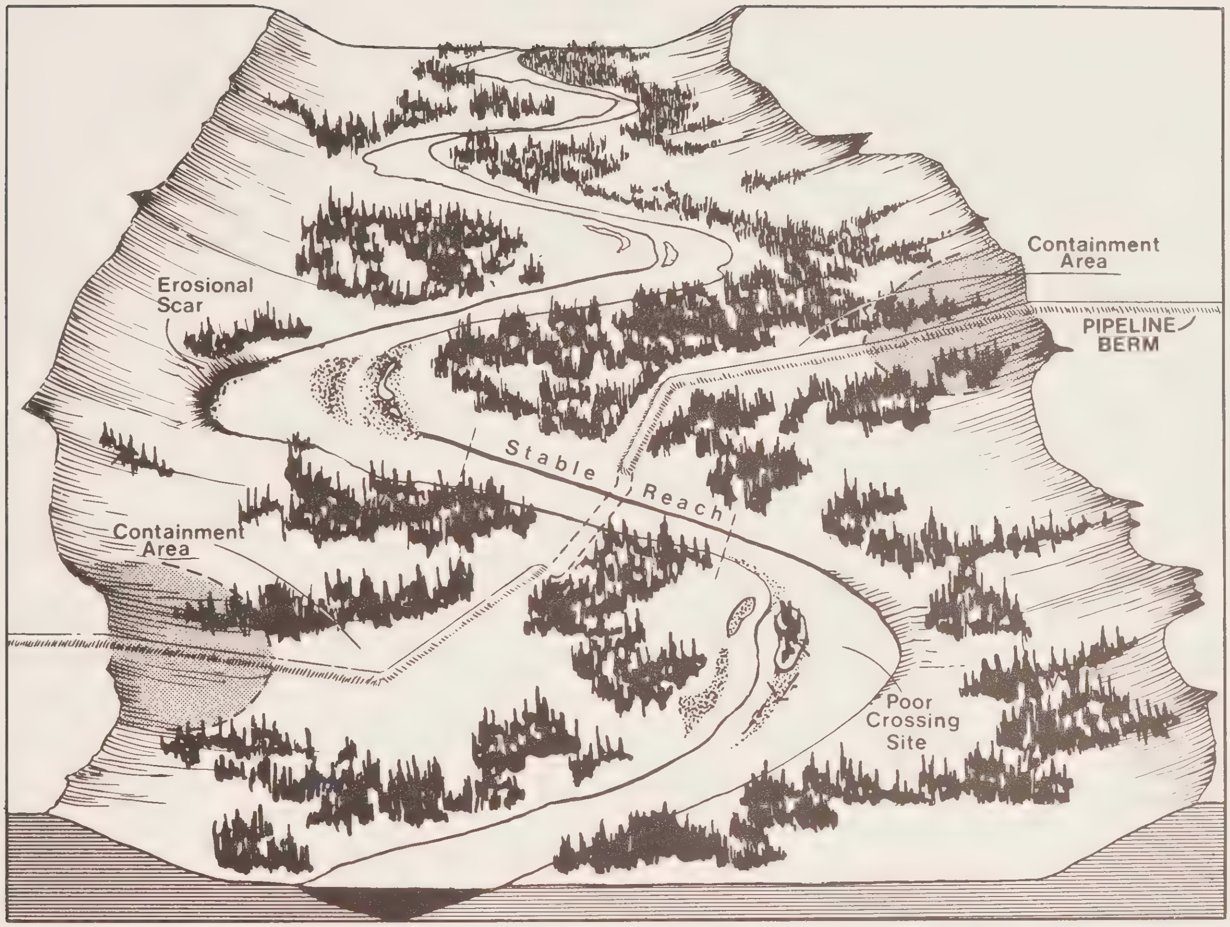

Crossing location to avoid river siltation.
The river banks are stable, and material eroded from either valley wall would be trapped on the low bench bordering both sides of the river.

8.9 DRAINAGE AND EROSION CONTROL

Background

Despite considerable petroleum exploration activity during the past 15 years, the region traversed by the proposed pipeline retains a wilderness aspect. Erosion, through scarring of the landscape and siltation of streams and lakes could lead to significant deterioration of both aesthetic and environmental quality, and hence is of concern with regard to the proposed pipeline development.

As explained in the topic "Slope Stability and Erosion Susceptibility", soil erosion, whether natural or man-induced, is virtually restricted to exposed soil surfaces that lack the protection afforded by the surface organic layer and root mat. The extent to which the organic layer and root mat will be removed either by deliberate stripping, or as a secondary effect arising from construction of the pipeline and other facilities, therefore provides a measure of the *potential* extent of erosion.

Where "conventional" winter construction methods are proposed, generally south of 65^{o}N. Lat. (*see* topic "Arctic and Conventional Construction Methods"), the entire width of the right-of-way will be stripped and graded. Where "Arctic" winter construction methods apply (generally north of Lat. 65^{o}N.), a width of 12 to 15 feet will be stripped and graded along the pipe centreline to provide a working surface for ditching equipment, and the disturbed soil will be replaced, forming a berm about 15 feet wide and two feet high. Additionally, where grade cuts or sidehill cuts are required to provide a working surface and traffic lanes, a much greater width will be stripped and graded. Permanent roads will be mostly of embankment (pad) construction; however, insofar as location of roads can be determined from information supplied, a significant total length of grade and sidehill cuts will be required. Individual borrow pits may require stripping of areas up to 200 acres, depending upon the thickness of available suitable material and volume required.

Vegetation can also be removed as a secondary effect of construction, thereby exposing soil to erosion. Diversion of drainage by ditches or diversion dikes can concentrate surface flow to the point where it disrupts the organic layer and root mat, initiating gully erosion. Embankment roads and backfill berms over the ditchline can, inadvertently, have the same effect if culverts under the road or breaks in the berm are too few or are not located where needed. Large pads and airstrips can also divert and concentrate drainage, but in this case, breaks or culverts do not offer a practical remedy.

Cuts, especially sidehill cuts, by oversteepening the slope, can initiate shallow slope failures, exposing soil to sheet erosion and gullying; mere removal of trees can lead to deepening of the thawed active layer in permafrost areas, and initiate shallow failures, again exposing soil to sheet erosion and gullying. Where cuts or shallow failures expose ice-rich soil, the scar commonly expands headward by retrogressive thaw, increasing the area subject to erosion.

Thermokarst subsidence is commonly associated with erosion in permafrost terrain, and has similar causes. The subsidence results from melting of segregated ice in permafrost soil either when the insulating organic layer is removed or when water is impounded on the surface, thereby increasing the absorption of heat into the ground. Surface water can be impounded where either breaks in the backfill berm or culverts under road embankments are inadequate in number or location, or where large pads or airstrips impede the drainage. Frost heave where the chilled pipeline crosses

unfrozen soil could also result in ponding of surface water.

Applicant's Data

The Applicant's measures to minimize erosion fall into three categories: (a) protection of exposed erodible soil surfaces, (b) diversion of surface drainage away from exposed erodible soil surfaces onto undisturbed vegetated terrain, and (c) maintenance so far as possible of natural drainage in order to minimize drainage concentration and ponding.

The principal measure in category (a) is revegetation. Most stripped areas will be seeded with grass mixtures and fertilized. In some tundra areas, the organic layer may be stripped prior to ditching and replaced after the ditch is backfilled. Some cut slopes will be revegetated by hand planting of shrub cuttings, or laying of preseeded soil-binding mats. Less erodible granular material will be used to protect erodible soil where drainage is concentrated, as at breaks in the backfill berm (see below), along the upslope margin of the backfill berm or road embankments, at the outlets of culverts, or on steep slopes where revegetation might provide inadequate protection. Logs and brush removed in right-of-way clearing might also be used under most of these conditions as a substitute for granular fill. Granular backfill will be used in place of native backfill on slopes where the native backfill might become unstable and slump or flow, leaving an open ditch in which drainage and erosion would be concentrated.

Measures in category (b) include diversion dikes constructed of granular material, sand bags, or soil and vegetation debris; the dikes would be used where necessary to divert large volumes of run-off from the right-of-way to adjacent uncleared and undisturbed ground. Where the angle between the pipeline orientation and the fall-line of the slope is small (less than 10^{o}) dikes will be placed in chevron formation on both sides of the pipeline. Under such circumstances, mound breaks will be useless and unnecessary. Where the angle is greater than 10^{o}, dikes will be located only on the upslopes side of the backfill mound, with an orientation to ensure downward drainage to undisturbed ground. In non-permafrost soils and thaw-stable soils, shallow ditches, lined as necessary with granular material, will be used as an adjunct to the dikes where large flows are anticipated. Interceptor ditches could be placed along the top of excavated slopes to prevent erosion of the exposed face, as an alternative to protecting the face with granular material or logs and brush. Ditch plugs constructed of impervious materials such as fine-grained silty clays, or bentonite-enriched backfill soils will be placed across the pipeline ditch wherever there is a possibility that water may flow through the ditch backfill, thereby causing erosion and melting. The material will be placed either in sacks or between forms and will be keyed into the walls of the ditch to prevent significant seepage around the ends. The plugs will usually be located on the downslope side of the mound breaks but closer spacing may be needed to prevent flow through or along the backfill.

Measures to maintain natural drainage (category (c)) include provisions of breaks in the berm over the pipeline at all natural drainage ways. Alternatively, existing microdrainage ways will be maintained by installing a gravel cap on the berm, through which both surface and subsurface flow could cross the ditch line. Bridges or culverts will be provided at natural drainage ways crossed by road embankments; where required, culverts will be designed to provide for fish passage and will be double-stacked where icing is anticipated. Cross-ditching of the roadway, with shallow ditches armoured with coarse aggregate, is proposed as a substitute for culverts where the road crosses

numerous poorly defined drainage ways.

General criteria for application of erosion-control measures are described in Section 8.b.1.3.8.4. Eight categories of erosion control are described. One category, EC-5, is not strictly an erosion control measure, but rather prescribes deeper burial where the pipeline crosses alluvial-fan or alluvial-cone deposits in order to avoid pipe damage by natural erosion. EC-6 describes conditions (sidehill cuts) under which unstated control measures will be applied. Tentative application of the measures is shown on the Alignment Sheets except at valley crossings. However, final application of the measures, and details of their design, will be based on topographic, geotechnical and hydrologic data not now available. The actual location of erosion-control measures will be determined by ground survey and marked before construction commences. The location work will be carried out during early summer when the drainage courses are flowing and are not obliterated by snow. The spacing, orientation and location of the diversion dikes will be determined in the same way but may be modified at the time of construction when ditching exposes subsurface conditions (Sect. 8.b.1.3.8.4.a).

Concerns

1. The Applicant appears to have anticipated most conditions that could lead to disturbance of drainage and erosion, and has developed measures to minimize and mitigate undesirable effects. However, no assessment is provided on the possible effects of frost heave or icing on drainage (*see* topic "Chilled Pipeline" and "Springs and Icings") or of possible ensuing effects such as erosion or ponding and thermokarst subsidence.

2. For some proposed control measures, there is uncertainty regarding their probable effectiveness and/or potential side effects:

- Effectiveness of revegetation, primarily by grasses, in binding erodible soils has not been tested adequately under conditions where revegetated areas were actually subjected to erosion; field experiments have emphasized measurement of herbaceous growth rather than effectiveness of the root systems in inhibiting erosion (*see* topic "Revegetation"). Temporary measures could be used to control erosion until new vegetation is well established.

- Diversion dikes and ditches, and interceptor ditches may prove effective in minimizing erosion along the pipeline and roads, but under some slope conditions they may serve to concentrate surface drainage and may initiate erosion beyond the right-of-way of either pipeline or road.

- Where granular material is used as selected backfill or to armour erodible soil, thaw penetration and potential for subsidence will be greater than for most native soil, particularly if percolation of water through the granular material results in convective transfer of heat to soil below the gravel. A mixture of topsoil and vegetation debris might prove effective for some conditions where granular armour is proposed and should reduce rather than increase thaw penetration.

- Proper placement and compaction of ditch plug material may prove difficult under winter conditions.

3. The broad range of control measures proposed appears to ensure that acceptable measures or combinations of measures are available to meet nearly all possible conditions. However, effective matching of control measures to field conditions will depend on the availability of detailed topographic, geotechnical and hydrologic data. Given those data, effective matching will still be

difficult, because of virtually limitless combinations of field conditions. Success will depend to a large extent on local experience of location engineers.

4. Erosion problems will undoubtedly arise in the spring and summer following the first winter of construction, before vegetation has become re-established and before backfill has become consolidated. Close monitoring of the performance of control measures during that summer would provide valuable guides for improvement of both design and application of control measures along those parts of the pipeline built in later years. However, the Applicant makes no specific reference to an ongoing program by which performance data would be incorporated into final design for the later years of construction.

5. Contingency measures, proposed by the Applicant to be applied where original control measures prove inadequate, are essentially additional applications of the various measures already described. Surveillance will provide for early detection of erosion or drainage problems. There are several points to be noted about the proposed procedures.

(i) Weekly surveillance is mentioned as a possibility during spring break-up. However, the Applicant has indicated that surface erosion during spring run-off will be less severe than that caused by storm run-off during the summer when the surface soil would not be frozen (Sect. 8.b.1.3.8.1). Therefore the surveillance schedule needs to be flexible enough to permit immediate detection of the results of summer storms.

(ii) The possibility of summer storms needs to be considered in any decision to postpone corrective measures until freeze-up. A summer flood across erosion scars that had been initiated during spring run-off could lead to further disturbance.

(iii) It is presumed that stockpiled gravel can be used to armour mound breaks or the upslope side of the backfill mound and to fill in depressions that may develop over the pipe. Furthermore, erosion control mats can be brought in by helicopter. However there is no indication of how additional diversion dikes or rip-rap could be installed without going outside the right-of-way for vegetation debris or digging up naturally vegetated or revegetated soil.

Highlights

1. As discussed under other topics ("Slope Stability and Erosion Susceptibility"; "Arctic and Conventional Construction Methods"; "Construction of Pipeline Facilities and Roads") potential for erosion can be significantly reduced in the final design stage by refinement of location of the pipeline and facilities to avoid terrain and drainage conditions that exacerbate erosion problems, and by adopting construction methods that minimize disturbance of vegetation.

2. The Applicant's proposed erosion-control and drainage measures, singly or in combination, appear to provide for adequate control of identified erosion and drainage problems, except for disruption of drainage if frost heave or icing occurs along the right-of-way. Assessment of the probable magnitude of this problem and design of control measures would logically follow on completion of the Applicant's current research on frost heave (*see* topic "Chilled Pipeline").

3. Some inadequacies or misapplication of control measures, and resultant aesthetic and environmental damage, is virtually certain, especially

during the first construction year. Erosion will be concentrated in the first year or two, until revegetation becomes increasingly effective as a control measure. Staging of construction over three winters affords an opportunity to base the improvement in design and application of control in the second and third years upon an assessment of performance of measures employed in the first winter. Active participation of design and field engineers in intensive monitoring programs would ensure that experience gained from the first stage of construction would be incorporated in subsequent stages. For the specific problem of interruption of drainage by frost heave, effects may be slow and cumulative over a long period. If so, there will be opportunity for improvement of control measures over an extended period.

4. Lack of detail on surveillance procedures and contingency measures raises concern as to whether erosion and drainage problems can be identified and remedied effectively before severe damage results, and without concomitant additional damage due to the contingency measures themselves. Thus in any later review of drainage and erosion control, particular attention to surveillance and contingency measures would be important.

8.10 SPRINGS AND ICINGS

Introduction

Groundwater flow, as manifested in springs, seeps, ground icings, river icings, baseflow in rivers and lakes or ponds with mineralized water, may pose a variety of environmental and engineering problems for the pipeline and associated facilities. Icings are surface masses of ice formed during the winter by successive freezing of sheets of water that seep from the ground or a spring or a river. Problems of icings at river crossings are discussed in the topic "River Crossings" and direct drainage disruption resulting from chilling of the buried pipeline are dealt with in the topic "Chilled Pipeline". The present topic concentrates on ground icings, groundwater, and springs in relation to the pipeline.

In the zone of continuous permafrost, groundwater flow is mainly in the active layer. Groundwater flow becomes progressively more important southward in the Mackenzie Valley as the active layer thickens and the permafrost becomes discontinuous. Icings from groundwater take many forms. Some are local sheets of ice near the base of slopes where spring water spreads over the ground surface. Others are extensive tabular ice masses, formed where groundwater emerges in winter from beneath a river channel. Icings continue to increase in thickness and extent throughout the winter as long as the water flows. During the summer the ice melts and the water runs off. Some icings are so voluminous that sizeable remnants persist throughout the summer; others disappear in the summer and form again during the succeeding winter. Locations of icings tend to be approximately the same, year after year. Icings influence the hydrologic regime of nearby streams by storing water during the winter and releasing it slowly during the summer; winter and spring flows in nearby rivers are reduced, and summer and fall flows are increased.

Springs occur where groundwater emerges at the surface. Some springs freeze in the winter and produce icings, whereas in others the water temperatures are high enough to maintain local open water areas at the surface throughout the winter. At some springs, strong upward hydraulic pressure maintains "quick" conditions in the surrounding soil.

Applicant's and Other Data

The Applicant has presented a series of small-scale maps on which locations of springs near the proposed pipeline route are shown (Sect. 14.d. N.4.7). These maps show a particularly large number of springs at the base of the western slopes of the Norman and McConnell ranges between Donnelly and Willowlake rivers.

In addition to the above data, a series of maps is being prepared at a scale of 1:250,000 to show locations of springs and icings throughout the Mackenzie Valley (van Everdingen, 1974). Brief notes accompany these maps. Those maps covering parts of the Prime Route in the northern Yukon and along the east bank of the Mackenzie River between Gibson Gap and Bear Rock have already been made public.

Where icings may interfere with roads, the Applicant proposes to force the icings to form upslope. Provisions will be made to allow the meltwater from icings to run off in the summer without causing accelerated erosion. To provide adequate capacity in case of icing at culverts, at least two pipes will be provided at

each location. The lower one will be located at ground surface, with the bottom of the upper pipe being set above the top of the underlying pipe. Where potentially severe icing conditions are identified, several culverts will be provided in "stacked" configuration (Sect. 8.b.1.3.8.4.1.d).

After operation of the proposed pipeline commences, the gas would be chilled below the freezing temperature of water. The Applicant has recognized that the frozen annulus around the pipe may constitute a barrier to the passage of groundwater across the right-of-way and may result in the initiation of new icings. As there is no reliable method to pre-determine those areas that may experience icing, the Applicant has proposed to use available techniques after the line is in service to inhibit or eliminate such icings (Sect. 14.d.N. 7.3).

The Applicant's design is intended to provide for passage of surface water across the right-of-way through breaks in the berm; groundwater would flow across the right-of-way through permeable backfill in the ditch (Sect. 14.d.N.7.2.2).

Concerns

A broad range of environmental concerns related to springs and icings (see below) is compounded by the difficulty in predicting the occurrence and severity of icings and other groundwater-related problems. Part of this difficulty is due to the lack of information regarding the distribution and characteristics of springs and icings in the Mackenzie Valley; part is due to general lack of construction experience in coping with these problems in cold regions. Carey (1973) has noted that such prediction will be difficult until the basic understanding of the causes and patterns of icing development is improved.

Groundwater discharge is certainly more widespread than is shown on the maps (van Everdingen, 1973). For example, there are a large number of springs, areas of winter open water, mineralized lakes, and other manifestations of deep groundwater discharge shown on the Groundwater Data Mapsheet for Norman Wells (van Everdingen, 1974). They tend to be confined to a long narrow band some distance downslope from the base of the Norman Range. The proposed pipeline right-of-way is generally within a mile of these features and crosses the band at least four times. Notes accompanying the map-sheet state that the widespread occurrence of springs, perennial groundwater discharge into streams and related spring and stream icings in the corridor between the Mackenzie River and the Norman Range, from Bear Rock to Gibson Pass, indicate a high probability that land-use activities will encounter groundwater-related problems in this part of the transportation corridor. If the groundwater discharge zone were narrow the problems would only occur at the points where the pipeline crosses it. The problems could include "quick" conditions, frost heaving of the pipe, slope instability and icings, all quite localized. If the discharge zone were two miles wide, however, almost all of the 70 miles of pipeline route on the map-sheet would be affected, resulting in potentially severe construction and maintenance problems.

The Applicant's assessment of icings and other groundwater-related problems appears to be that they will be sporadic and localized in nature so that available techniques could be utilized to inhibit or eliminate the problems, after problem areas have been identified when the pipeline is in service. The proximity of the pipeline route to the line of groundwater discharge manifestations in the Norman Wells area provides some indication that such measures could be very expensive. The relatively experimental measures

required would likely not always be successful, and the consequences of their application may be unacceptable from an environmental point of view.

From the small-scale maps presented by the Applicant (Sect. 14.d.N.4.7) it appears possible that similar conditions could be encountered along much of the pipeline route between Donnelly River in the north and Willowlake River in the south, a distance of almost 300 miles. North of Donnelly River the groundwater-related problems should not be so prevalent, occurring principally at stream crossings and in sedge fens. South of Willowlake River, where permafrost tends to be sporadic, the chilling of the pipeline as far south as latitude 60°N. could lead to widespread groundwater-related problems. However, the groundwater discharge areas there are more diffuse, slopes are less steep, and more rivers have winter channel flow. Therefore, the main problem may be frost heaving of the pipeline, and small local icings.

Some specific concerns related to springs and icings are outlined:

(i) ditching in an area of groundwater discharge could lead to development of "quick" conditions in the trench or, if the groundwater was confined under pressure by the frozen surface layer, to overflow of the ditch and the formation of ground icings. Buoyancy problems may be experienced with the pipe;

(ii) aufeis formation at stream crossings or extensive ground icing formation along the pipeline right-of-way could reduce winter flow of water into important over-wintering areas for fish. There is also a danger of increased siltation of streams due to slope instability and to the inhibition of revegetation by extensive ground icings;

(iii) the frost bulb around the pipeline could impede the passage of groundwater across the right-of-way. It is considered likely that an initially permeable backfill in the ditch could become relatively impermeable if it were water-saturated and frozen by the chilling effect of the pipeline. Such a blockage of groundwater flow would raise water tables upgrade and could result in local ponding, accelerated erosion due to concentration of surface flow, and creation of winter icing conditions.

Highlights

1. The wide variety of environmental and engineering problems that can be associated with construction in the vicinity of springs and icings make it desirable that, as much as possible, the pipeline route avoid existing natural icings, natural springs and seeps, and sites where appreciable groundwater flow is detected.

2. The safest design principle would be that which would disturb the groundwater regime the least.

3. Potential interactions between icings initiated by the chilled pipeline and other adjacent works, such as the Mackenzie Highway, deserve careful consideration.

4. The possibility of producing extensive icings in environmentally sensitive areas points to the advisability of carrying out further detailed groundwater investigations in the vicinity of springs and in stream channels where there is little or no winter flow. The prediction of

extensive aufeis formation at stream crossings would also require further geothermal investigations into the formation of a frost bulb around a chilled pipeline in the presence of convective transfer of heat by flowing groundwater and surface water. If such investigations were to indicate a high probability of initiation of extensive icings, consideration should be given either to rerouting the pipeline or to using a different construction mode.

Literature Sources

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8.11 SNOW AND ICE ROADS

Introduction

The cross-country movement of heavy, especially wheeled, vehicles in the permafrost areas of the north is generally restricted to those months when the active layer is frozen. Even at these times, however, the movement of equipment and materials necessitates the use of certain techniques of ground preparation to minimize the damaging effect of such localized and intense traffic on the terrain. The most common approach has been to construct a smooth-surfaced, compacted snow road capable of supporting the heavier wheeled or tracked vehicles. The success of these roads in minimizing disturbance has been variable (Kerfoot, 1972).

The installation of the gas pipeline will require extensive transportation facilities to meet project deadlines; snow roads are an important and integral part of these facilities. In those areas where special Arctic construction techniques are to be used (*see* topic "Arctic and Conventional Construction Methods"), snow roads will be used by the Applicant for all traffic along the right-of-way and for access to the right-of-way, borrow pits, wharves and stockpile sites, except where permanent roads are built.

The major environmental concern of the Assessment Group stems from the Applicant's need to exploit fully the available winter season and to accumulate the year-to-year variation and uncertainty that occurs in snowfall and other climatic factors. Appreciable terrain disturbance and environmental harm can be done in early winter if attempts are made to construct snow roads before snow and frost conditions are suitable, and the same danger is present in spring if the roads are used longer than they are suitable for traffic. This and related concerns are discussed below, taking into account that certain information on the Applicant's procedures is absent and had to be made the subject of "Requests for Supplementary Information".

Applicant's Data

In the development of construction procedures, the Applicant concentrates on minimizing disturbance of the terrain cover (Sect. 13.a.6.8). He states he "...has developed techniques which can be used to prevent or control such undesirable changes as soil and thermal erosion" (Sect. 14.d. N.2.1). Snow and ice roads are regarded as "successfully tested" (Sect. 14.d.N.7.3) construction techniques which will prevent the destruction of the insulative properties of the surface vegetation and the underlying insulative organic mat. A protective work or travel surface is to be provided by snow and ice roads along the right-of-way or any access not served by a permanent road (Sect. 14.d.N.6.3.2).

Snow and ice roads were constructed and evaluated by the Applicant during the installation of test facilities at Prudhoe Bay (Sect. 8.b.1.3.5.3), Sans Sault (Sect. 8.b.1.3.5.4), and Norman Wells (Sect. 8.b.1.3.5.5). In addition, a winter road research loop was constructed and tested at Norman Wells in March and April of 1973. Ice, processed snow, and ice-capped processed snow roads were evaluated for relative performance under conditions of simulated pipeline construction traffic.

From these tests, and other information, the Applicant concluded that processed snow roads would perform adequately. Such roads would be used in areas of high ice-content permafrost to provide access to rights-of-way, borrow pits, stockpile sites and wharves, and to provide a traffic lane for

construction along the side of the right-of-way (Sect. 13.a.6.4.1). In areas of conventional winter construction—generally south of 65°N. (Sect. 14.d.N.5.3.1)—snow and ice roads will not be built, but this does not seem to agree with the proposed construction schedules that show snow and ice roads for all construction spreads north of 61°N. (Sect. 13.a.2.3.1, Figs. 2-9).

Two types of snow road will be required. The first, to be used for all access roads and the traffic lane on the right-of-way, is to be wide enough to accommodate two parallel lanes of traffic and strong enough to support a heavy volume of traffic. The second type, less dense and less smooth than the first, will provide a working surface adjacent to the pipeline for slow-moving construction equipment. The preparation of snow and ice roads is described briefly in Sections 13.a.6.4.1 and 14.d.N.5.3.1; but the equipment required to do so has not so far been described. Detailed specifications are to be developed by the Applicant, then incorporated into the contracts awarded for the construction of such special Arctic tasks as snow roads (Sect. 13.a.4.1).

Snow and snow-and-earth fills may be required to achieve suitable work surfaces for construction equipment. Their use is described in Section 14.d.N.7.6. Where break-through or rutting requires repair, snow and water will be added (Sects. 13.a.6.4.1; 14.d.N.5.3.1).

The Applicant expects that clean-up and restoration needs will be minimal (Sect. 13.a.6.4.1). The road will melt and run off and stream crossings and any snow fills that could interfere with drainage will be removed (Sect. 8.b.1.3.8.4.1). Where the vegetative mat has been damaged by breakdown of the road surface, the area will be seeded.

The environmental impact of snow and ice roads is expected to be minimal (Sect. 8.b.1.3.8.4.1) and confined to some compaction of the organic mat, the loss of a few living plants, and on some slopes a degree of minor erosion due to mechanical breakage (Sect. 14.d.N.7.6). Compaction of the organic layer may lead to a deepening of the active layer but the Applicant expects that this will not be serious compared with normal variation that exists in the depth of the active layer. In some areas thaw settlement may occur requiring the construction of diversion dikes able to direct drainage to virgin ground adjacent to the right-of-way (Sect. 8.b.1.3.8.4.1).

Concerns

Pipeline Construction Schedules

Considerable but unnecessary terrain damage could result during the preparation of snow and ice roads if the Applicant adheres to his proposed construction schedules (Sect. 13.a.2.3.1, Figs. 2-9). The schedules do not take into account the variations in climate that occur between localities and successive years, nor do they seem to utilize the available information on snow cover (Potter, 1965). Before the preparation of snow roads can begin there must be sufficient frost penetration to support the vehicles and there must be sufficient snow cover to prevent surface disturbance by these vehicles. Moreover because stream and drainage channels freeze more slowly than intervening areas they act as barriers to vehicle movement and delay road preparation. These problems can be avoided if the starting time for snow-road preparation is determined by the depth of frost penetration and snow cover and not by a fixed date set in advance. Adams (1972) has concluded that at least several inches of frost-penetration and eight inches of snow are required to avoid damage.

Snow and Ice Road Construction

The Applicant has not discussed the following possible environmental impacts resulting from snow and ice road construction.

Accelerated Frost Penetration and Snow Compaction. The types of low-ground-pressure vehicles proposed by the Applicant to accelerate frost penetration during freeze up and to level and compact the snow could cause harm if used on too shallow a snow cover. Where small-scale earth hummocks occur—generally north of Fort Good Hope (Zoltai and Tarnocai, 1974)—the movement of tracked low-ground-pressure vehicles or snow-compaction equipment across the crests of the hummocks could tear up the surface organic layer. The sensitivity of earth hummocks to such disturbance and the consequences have been discussed elswhere (*see* topic "Vegetation Clearing", and Zoltai and Tarnocai, 1974). This problem can be avoided by delaying the preparation of the snow road until the snow cover is deeper or by using different equipment. Low-ground-pressure vehicles with flotation-type tires rather than tracks are preferable, as are "floating drags" for levelling and compacting the snow.

Snow Accumulation and Harvest. Where meteorological data indicate light snowfalls, it is proposed to supplement the normal snowfall with accumulated or harvested snow (Sect. 13.a.6.4.1). There is concern that if snow harvest is from adjacent land surfaces, disturbance could extend considerably beyond the right-of-way. This practice will probably be necessary on the treeless tundra where much of the surface is patterned (polygons and earth hummocks) and highly susceptible to disturbance by the snow-harvesting vehicle. The more so because snow harvesting here will occur when only a light snow cover is present to protect the ground surface. The danger of snow harvesting can be minimized if the technique is used only when absolutely necessary and only if it is certain surface damage will be minor. In forested areas, and elsewhere, snow may also be harvested from lake surfaces. The environmental implications of this procedure are as yet unknown.

Ice Roads. Where snowfall is insufficient to prepare a snow road or for other reasons a suitable snow road cannot be prepared, ice roads are proposed (Sect. 13.a.6.4.1). Such areas are most likely north of Little Chicago (Potter, 1965), where much of the ground surface is patterned, primarily with small-scale earth hummocks. Construction techniques are insufficiently described by the Applicant, but concern centres on two aspects:

(i) the amount of surface disturbance occurring during the construction of ice roads, especially in areas of earth hummocks;

(ii) the volumes and sources of water required to construct an ice road capable of supporting heavy traffic without disturbance to the terrain. A simple calculation shows that an ice road two inches thick and 32 feet wide requires 176,000 gallons/mile; in hummocky areas much larger volumes will be needed, with increased possibility of harm to fish in the waterbodies from which the water is taken.

Cuts in Permafrost. The Applicant indicates that where "design factors" dictate, cuts will be made in permafrost "...to permit passage of construction equipment over severe changes in gradient" (Sect. 8.b.1.3.8). However, he has not specified the maximum acceptable gradient for snow and ice roads for: (i) the transportation of materials; and (ii) pipe construction, laying,

and testing, nor has he indicated where such cuts may be required. Such cuts are most likely to be required on sloping valley walls and river banks where ground instability resulting from thaw of permafrost or erosion could threaten the integrity of the pipe or lead to siltation of the river.

Drainage and Erosion Control

There is concern that by intercepting spring run-off, snow and ice roads could concentrate and channel drainage and start erosion, a phenomenon described by Lewellen and Brown (1969) and commented on by Adams (1972). This would be most serious on slopes and approaches to stream crossings because of potential hazard to the pipe and siltation of the stream. Concern arises, too, over the proposed drainage-control measures in areas where thaw settlement of the ground is expected following snow and ice road use (Sect. 8.b.1.3.8.4.1). Diversion dikes are planned to divert water off the area of the snow road onto adjacent undisturbed vegetation. Such dikes could cause ponding on the snow road right-of-way leading to permafrost degradation and the development of thermokarst.

Highlights

1. The construction of the pipeline and its ancillary facilities will involve the preparation and use of many miles of snow and ice roads for winter transportation of equipment, materials and supplies. Such roads will be used primarily, but not exclusively, in the more northerly areas where permafrost is abundant and where the Arctic type of construction is to be used for pipeline development.

2. Much terrain damage, leading to erosion and siltation, could result from a fixed schedule for building snow roads rather than one that is determined by the particular climatic characteristics of the winter in question. Normally, several inches of frost penetration and at least eight inches of snow are required if snow-road preparation is to avoid terrain disturbance.

3. During the preparation of snow roads disturbance of the ground surface can occur, especially on hummocky ground terrain north of Fort Good Hope, if unsuitable low-ground-pressure vehicles are used on too shallow a snow cover. On such areas damage can be reduced by waiting for additional snow and by using flotation-type tires with floating drags for levelling and compacting the snow.

4. Where snowfalls are light, and snow to build up the road is taken from nearby areas, there is the danger of terrain disturbance to the source areas, especially in the treeless tundra. Harm will be minimized if the technique is used only when absolutely necessary and with the utmost care.

5. Concern over ice roads is centred on ground disturbance during construction, especially in areas of earth hummocks, and disturbance of sensitive aquatic habitats in winter by removal of large quantities of water for building the road.

6. Melting of snow and ice roads may interfere with the normal spring run-off and drainage patterns, especially on slopes where channeling may lead to erosion and siltation. Interim drainage-control measures could prevent this problem, provided the measures do not produce problems elsewhere, such as ponding.

Literature Sources

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Potter, J.G., 1965. "Snow Cover", Climatological Studies, No. 3, Meteorological Branch, Dept. Transport, Ottawa.

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8.12 ENVIRONMENTAL EFFECTS OF BORROW OPERATIONS

Introduction

The development of borrow pits for the extraction of natural materials is a necessary part of most construction projects. It involves the use of heavy earth-moving equipment and, in some cases, extensive crushing and grading plants; the operating pit areas can be noisy, dusty and unsightly. Borrow operations proposed by the Applicant will provide material for fill and pipe bedding as well as the sand and aggregate used in concrete work and for surfacing roads and other facilities. They will range from very small operations where only a few hundred cu yd of aggregate or fill required, up to operations where more than a million and a half cu yd of material are to be extracted from a single location. Materials are either unconsolidated (e.g. gravel) or in the form of bedrock. In some places materials will have to be hauled as far as 8 miles generally over temporary haulage roads constructed in winter from snow and ice. At some locations all-weather roads will be used. Most pits will be in use for only one winter season and perhaps only a few weeks within that period, and some will be used during one summer, but the few pits that will supply materials for maintenance purposes may be open for several years.

Borrow operations commonly have some undesirable impacts on the environment. Some impacts may be restricted to the extraction period but others are of a long-term or even semi-permanent nature. The problems associated with pit development are wide ranging and well known. Pits may pre-empt terrain that could be used for other purposes, destroy animal habitat or stand as aesthetically displeasing evidence of the operation for many years after completion of the construction project. Borrow operations in the north involve certain environmental problems not encountered in southern Canada. In permafrost areas excavation of frozen sand and gravel may require blasting, resulting in high noise levels generally associated only with quarrying operations in bedrock. When ice-rich frozen materials are excavated and placed during winter, thawing and subsequent drainage in summer may lead to settlement and flow and this situation is further aggravated when materials are placed over snow. Similarly, cut faces in ice-rich materials and piles of spoil or waste, may thaw and flow. The problems outlined above make the rehabilitation of borrow pits in permafrost areas more difficult and costly than in non-permafrost localities.

This description of the environmental effects of borrow-pit operation has identified a large number of concerns. Many of the critical impacts, however, can be avoided or reduced in importance if careful attention is given to location, scheduling of operations and rehabilitation. This is a process which requires close cooperation between specialists in inter-related fields.

Applicant's and Other Data

The Applicant estimates that his project will require 30 million cu yd of borrow material (Sect. 14.d.N.2.2.1, p.8), and 126 borrow pits and alternates have been located on the Alignment Sheets and/or on the less detailed Proposed Route Maps (Sect. 13.a.2.2) of the Application. However, as was noted in "Requests for Supplementary Information" (#29), many facts needed for assessment of the environmental impact of borrow-pit operation are omitted. For example, the Applicant does not state how large individual pits will be nor how much material will be extracted from each; boundaries for individual pits are not delineated

and the season or length of time pits will be in use is not clearly stated. No information is provided regarding the quality or grade of material to be taken from each pit by the Applicant.

In the absence of the above information, the Assessment Group has worked from inferences regarding these matters, based upon the exhibits accompanying the Application. Although the Applicant has identified 126 borrow sources, several additional sources are assumed to be required in a few long stretches where no pits are shown and at a few places, e.g. Fort McPherson, where certain facilities are planned and/or a figure for borrow needs is given, but no source is indicated.

Location and Identification of Principal Pits

By taking the figures in the Land-Use Tables which accompany the Proposed Pipeline Route Maps (Sect. 13.a.2.2) and allocating them to the pits nearest to the major construction areas, the Assessment Group has identified 37 large pits or areas of extraction (i.e. areas from which more than 100,000 cu yd are to be taken). These are tabulated in the accompanying Inventory of Proposed Pits.

Timing

Most pits will be operated during one winter season, thus minimizing environmental impact. However, those pits which serve as supply sources for maintenance work must remain open year round throughout the operating life of the pipeline (Sect. 14.d.N.2.2.1, p.8). The Assessment Group has not been able to identify these positively but has inferred from the Pipeline Construction Schedules (Sect. 13.a.2.3.1, Figs. 2-10) and from camp utilization dates some pits which will be used during the summer (*see* the Inventory for individual identification).

Access

The Applicant does not give a detailed route for access to each pit. He does, however, give a general route and indicates the length of the access road required. He states his general intention to minimize environmental impact and initiate protective measures, but does not comment on specific measures to be undertaken to implement his philosophy with respect to particular terrain conditions or wildlife. He states, for example, that "Careful design of roads will further minimize any effects" to fish by way of siltation (Sect. 14.d.N.7.7.1) but specific design requirements are lacking.

Environmental Effects

The Applicant indicates that environmental factors will be considered in the selection of borrow pits, for example: "Those sites which were chosen ...represent aggregate sources based on environmental, as well as engineering, considerations" (Sect. 8.a.1.5, p.6), and "Final selection of borrow sources is dependent upon the environmental acceptibility of each site..." (Sect. 14.d.N.2.2.1, p.8). On the other hand, site-specific problems are not dealt with, and the way in which individual pits will be handled is omitted.

Such generality persists throughout the Application and all references to birds and mammals relative to borrow operations are characterized by it (for example, Sect. 14.d.N.7.8.1, p.41, Birds; 7.9.5, p.52, Woodland Caribou; 7.9.6, p.53, Moose; and 7.9.7, p.55, Arctic Fox). The Applicant intends to change the environment as little as possible and to avoid those areas which are known or potential mammal or bird habitat.

Potential scheduling and noise problems are covered

with such statements as borrow pit operations will be carried out "...after freeze-up when most birds have left the Arctic" (Sect. 14.d.N.7.8.1, p.41). The Applicant recognizes that some habitat will be lost: "Anticipated long-term changes in habitat include...some permafrost degradation with ponding and/or draining of water off some areas associated with haul roads, borrow sites..." (Sect. 14.d.N. 7.9.7, p.55).

Fish and Hydrology

The Applicant states that active flood plains will remain untouched (Sect. 14.d.N.7.8.1, p.41) but that it will be necessary in some areas to extract granular materials from inactive floodplains. "In these cases special precautions will be taken to limit siltation and ensure that no serious alteration of the normal river course occurs. No blockage or damming of rivers which would inhibit the passage of fish will be permitted" (Sect. 14.d.N. 2.2.1). The environmental repercussions of gravel removal from inactive river flood plains are not elaborated upon. The Applicant will ensure that run-off from pits does not enter water courses (Sect. 14.d.N.2.1.7, p.3) and that total habitat destruction by pit operation will be small (Sect. 14.d.N.7.8.1, p.41).

Revegetation and Restoration

Again, the Applicant's statements regarding revegetation and restoration are general. "Vegetation will be stripped off or covered up by borrow pits, haul roads and ancillary facilities. The extent and duration of most of these operations will be limited, and erosion control measures will be implemented in each case to avoid affecting surrounding areas" (Sect. 14.d.N.7.6, p.11). The Applicant acknowledges that pit operations will leave certain problems, for example, permanent changes in local relief and drainage patterns, and admits that thawing will occur in permafrost and ice-rich soil, resulting in possible soil instability (Sect. 14.d.N.7.2.2, p.2).

Restoration will be undertaken as soon as practicable following completion of construction (Sect. 13.a.6.8, p.58). Pits which have not accumulated water or which can be drained "will be restored by grading slopes to less than 4 degrees, placing organic or soil material on the surface and revegetating" (Sect. 14.d.N.2.2.1, p.8). In some cases the pit will be filled with stumps originally cleared from the site, and non-combustible debris from the right-of-way or other construction site, and debris buried by burden material originally stripped from the pit (Sect. 13.a.6.8, p.58). Plant cover will be re-established by seeding (Sect. 14.d.N.7.6, p.18). Where the pits have filled with water, "contouring and re-seeding of cover material will be done around the banks to encourage their stabilization as soon as possible, thus producing a naturally stable lake" (Sect. 13.a.6.8, p.58). "Borrow pits in low-lying wet areas will be reclaimed to provide new wet land habitat" (Sect. 14.d.N.6.3.2, p.8).

Other Data

Reports on granular resources prepared for the Department of Indian Affairs and Northern Development by consultants and by the Geological Survey of Canada appear to have been used extensively by the Applicant and in many places site numbers remain unchanged. However, the Applicant does not follow the consultants' format of treating every site on an individual basis and of supplying an environmental statement for each. These government data form part of the base information for borrow evaluation in this review.

Concerns

Comments on the environmental concerns involved

in each borrow pit proposed by the Applicant are contained in the Inventory at the end of this paper. Here the main kinds of concerns are presented in more general terms in order to highlight the questions relating to each source.

Mammals and Birds

There are two main areas of concern: first, the physical disruption of habitat and terrain changes, caused by clearing, excavation, spoil piles, drainage changes and access roads; and second, the noise and other disturbance from vehicles, machinery, blasting and the presence of man.

The first concern, applying principally to denning and nesting areas, involves denial of continued use of the site by the previous occupier. Such habitat destruction at some sites may lead to denial of future use by any species, but other sites may be suitable for the original or alternative species after restoration. The critical aspects are site location and site restoration and, thus, the concern can only be dealt with on a site-by-site basis.

The second concern involves only a temporary inconvenience and does not permanently destroy the habitat. Nonetheless, noisy activity may drive animals or birds away temporarily or permanently, leading to abandonment of breeding sites or young, modification of migration patterns and possible reduction in size of population. Evaluation of such impacts and design of measures to minimize disturbance are best undertaken site-by-site and species-by-species. The need is to avoid critical locations at critical times. Many of the Applicant's borrow operations are scheduled for winter and will avoid the critical periods for many species of mammals and birds. Nonetheless, some species (e.g., caribou, Dall's sheep, gyrfalcon and hibernating animals) are sensitive during winter and some pits are scheduled for summer operation. Moreover, adherence to planned schedules will be a matter of concern, particularly with reference to dates of start-up in the autumn and shut-down in the spring.

Fish and Aquatic Habitat

Borrow-pit operations can lead to disturbance of aquatic habitat and fish in rivers by raising silt levels in water, by siltation of river beds, by causing changes in the form of river channels, or by diverting low flow in winter. As in other biological concerns over borrow pits, the concerns are site-specific and are dependent upon time of year.

Borrow operations near rivers can cause siltation of the rivers in several ways. Muddy water may flow from the pit into the river, soil may be pushed or slide onto the river banks or development of the pit may cause slope failures. In permafrost areas, spoil materials or cut banks which are stable in winter can thaw to produce mud flows in summer.

Pits subject to periodic flooding are of additional concern in that passage of water through them can result in erosion or sedimentation, leading to changes in the river bed or banks.

Borrow pits in river channels present special problems but also have special attractions for those undertaking winter operations in the north. They do not require stripping of vegetation or spoil; the materials are not permanently frozen and commonly do not contain as much ice as permafrost materials; early in the winter the materials are not deeply frozen and thus can be piled and drained; and spring run-off will obliterate the pit, reducing cost of rehabilitation and leaving no scar on the landscape. Winter borrow operations

in the channels of rivers with no overwintering fish and no winter flow may or may not be detrimental to aquatic habitat or fish, depending upon the form and condition of the bed and channel following the spring run-off. In some situations the pit will be filled in and the river-bed habitat will be as suitable for fish and other aquatic organisms as before the borrow operation; in others, siltation or change in channel form may result in a less satisfactory habitat. Winter borrow operations in rivers with low winter flow or underground winter flow and with overwintering fish or winter-sensitive habitat, can, of course, be highly detrimental through changes in winter-flow patterns or increase in silt in the water.

In view of the foregoing, the Assessment Group considers that site-by-site assessment of each of the Applicant's proposed borrow operations in river channels and active flood plains will be needed to predict impact on fish and aquatic habitat, and that data presently provided by the Applicant are inadequate for effective assessment. Although, as indicated in the accompanying inventory of pits, it appears that some of the proposed sites potentially involve substantial impact, it may be possible to demonstrate that others will not.

Land Disturbance and Aesthetics

Borrow removal, by its very nature, results in large unsightly pits or exposed rock faces. In unconsolidated deposits such areas can be rehabilitated to a degree by partial refilling, reshaping, grading (contouring) and revegetation. Quarries pose a more difficult rehabilitation problem because of the extreme slope of quarry faces and the lack of suitable spoil on which to re-establish vegetation growth. The basic concerns are choice of borrow location and method of pit rehabilitation.

Pit operation in permafrost terrain presents the possibility of continued thawing of ground ice after the operation has closed down, possibly leading to soil erosion, destruction of vegetation, soil slumping, land subsidence and siltation of waterbodies. Thawing of spoil dumps may lead to similar problems.

The Applicant's proposals for rehabilitation appear to be appropriate but are presented in general terms only. However, in practical terms, the problems are of an individual nature and can only be treated on a site-specific basis. Without a site plan for development and restoration it is impossible to identify and assess environmental problems.

Land-Use Conflicts

Land-use questions arising from the Applicant's proposed borrow-pit locations involve archaeological sites; recreation and related areas; sites used by native people and borrow sources required for community or other purposes. Some conflicts can be resolved by effective scheduling and rehabilitation but others can only be resolved by use of alternate pit locations. Examples of the kinds of problems involved are contained in the topics "Archaeological Sites", "Borrow Material Resources", and "Recreation Areas, Parks and Land Reserves". Again, the prime need is for review of potential conflicts on a site-specific basis at the design stage of the pipeline project.

Inventory of Proposed Pits

An assessment of the potential for environmental and land-use impacts of borrow operations at all of the sites proposed by the Applicant is presented in the accompanying table. The table is divided into three sections reflecting the degree and nature of the concerns involved at each site and based upon whatever information the Assessment Group has

been able to find in the Applicant's documents and to obtain from other sources. In the absence of the definitive site-specific information identified in the foregoing as necessary for assessment of impacts of borrow pits, this *rating is highly subjective* and is *intended only as a first approximation.*

In the table, borrow sites are divided in three categories in terms of environmental concern: type 1 pits involving a high level of concern; type 2 with moderate concerns; and type 3 with low concerns. It is possible that as additional information becomes available some of the type 1 pits will move into type 2 and some of the type 2 pits into type 3. In the present inventory about one-half of the pits fall into types 1 and 2 and thus involve some substantial environmental concern.

It will be noted that more than half of the type 1 pits occur along the Prudhoe Bay lateral of the Applicant's proposed route and particularly the Yukon Coastal Plain section. This rating reflects the over-all high environmental sensitivity of the Coastal Plain, the coincidence of a number of mammal and bird concerns in this area, and the location of a number of proposed sites in river channels or flood plains.

Highlights

1. The Applicant proposes to develop 126 borrow operations, of which 37 will be large. The borrow operations and resulting pits are inevitably disruptive, but the negative effects can be substantially reduced by the choice of location, timing and rehabilitation.

2. Although a preliminary rating is attempted in the inventory tables presented in the attached Inventory, the impact of pit operation and proposals for location, timing and rehabilitation can only be assessed on a site-by-site basis based upon site-specific information. Substantial additional data are needed for an effective review. The Assessment Group considers that a definitive assessment of environmental impacts of individual pits, based upon such specific information, would be appropriate later in the approvals process, perhaps in connection with application for quarry permits.

3. Borrow operations disturb mammals and birds through physical disruption of habitat and through noise and related disturbances. Evaluation of such impacts and design of measures to minimize disturbance are best undertaken site-by-site and species-by-species. The need is to avoid critical locations at critical times.

4. Borrow-pit operations can lead to disturbance of aquatic habitat and fish in rivers by raising silt levels in water, by siltation of river beds, by causing changes in the form of river channels, or by diverting low river flow in winter. Special environmental concerns are presented by pits in river channels and on active flood plains. Some of the Applicant's proposals for such pits potentially involve substantial impact but others perhaps do not. The Assessment Group considers that each proposed borrow operation in river channels and on active flood plains requires individual justification based upon site-specific evidence of low impact on fish and aquatic habitat.

5. Additional concerns relating to borrow operations also may involve land-use conflicts over sites used by native people, borrow sources required for communities or other purposes, archaeological sites and recreation areas and land reserves. Further information on borrow-source conflict is contained in the topic "Borrow Material Resources".

6. In the accompanying Inventory, about one-half of the proposed borrow operations are tentatively indicated as involving substantial environmental concerns. A disproportionately large number of the pit sites on the Yukon Coastal Plain fall into this category.

INVENTORY OF PROPOSED PITS

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 1 PITS (Mainline)											
GM135	0					W	X				In Kendall Island Bird Sanctuary
GM137	83	X		X						X	Within boundary of town of Inuvik
DPW	97			X	R	R			X		In proposed protected area
374a	348				R		X		X		Uncertain location
P291	357	X	P289		M		X	X			P289 preferable
413	368									X	Reserve for community
P271	399	X			R			X	X		
P266X	401	X	P271		M		X	X			
P174	534	X	P170				X				Justify location in stream channel
GM87	680				M		X				Avoid river
TYPE 1 PITS (Prudhoe Bay Lateral)											
GM107	195				C		X				Justify location in active flood plain Within proposed IBP[6] site
124	199				C		X				Justify location in active flood plain Within proposed IBP[6] site
GM34	217	X		X	C W		X				Justify location if in active flood plain Within proposed IBP[6] site
125	224	X			C R		X	X			Justify location if in active flood plain Within proposed IBP[6] site
126	225	X	125		C R						Within proposed IBP[6] site
127	235				C R		X				Justify location in active flood plain Within proposed IBP[6] site
GM125	245				C		X				In channel?
133	269	X			R M		X				Justify location in active flood plain

[1] Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2] Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3] Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4] Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5] Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6] IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 1 PITS (Prudhoe Bay Lateral - cont.)											
GM47	298	X	GM46	X	W						Type 3 if proposed for waterfowl sensitive time
GM46	298	X		X	W						Type 3 if proposed for waterfowl sensitive time
137	307				R M		X				Justify location in active flood plain
138	317	X			R M		X				Justify location in active flood plain
142a	375				S?		X				Justify location in active flood plain
142	376				S?		X	X			Justify location in active flood plain
143	385	X			S						
147	407	X					X	X			Justify location, partly in channel Suggest alternative source north of river Within proposed IBP[6] site
244	458	X			R				X		Adjacent to travelled waterway, fishery
GM42	459	X		X	R				X		Adjacent to travelled waterway, fishery
TYPE 2 PITS (Mainline)											
GM134	23	X		X		F?		X	X		Adjacent to domestic fishery and travelled waterway
GM5	66					F?	X				Access road crosses creek
GM8a	126	X		X			X	X			
GM10	177	X		X	R			X			Traditional use area
300	180	X	GM10							X	Possible prior use by Mackenzie Highway
308	218	X						X	X		Traditional use area
321	251				R		X				Traditional use area
GM14	259	X							X		
326	269	X	GM14		M		X				Domestic fishery nearby

[1]Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2]Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3]Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4]Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5]Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6]IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

orrow it #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
YPE 2 PITS (Mainline - cont.)											
GH3	286	X	FGH2	X			X	X		X	Domestic fishery nearby. No fish/fishery concern if pit not close to Hare Indian R Within proposed Development Control Zone - Fort Good Hope
GH2	288	X		X				X	X	X	Aesthetic concern if visible from river Within proposed Development Control Zone - Fort Good Hope
74	342				R				X		
289	357	X		X	M		X	X			Traditional use area
W15	373	X	NW4	X			X		X	X	Within proposed Development Control Zone - Norman Wells
90	388						X				Stay out of creek
50BH	446	X		X					X		
213	479						X	X	X		Keep pit and access road away from slope
170	537	X					X	X			
143	584	X	P146				X				
109	642	X		X				X	X		
M121	655						X				Location uncertain
M25	717	X					X				
M83	785				R?		X	X			
M33	806						X				
M32	808	X					X	X			
M32a	808	X	GM32				X	X			

Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group).

Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 2 PITS (Prudhoe Bay Lateral)											
131	256				C	F?	X				
140	338				M		X				
GM128	375										Specific location uncertain
GM38	409	X	147				X				Within proposed IBP[6] site
GM129	477						X				Close to lake
TYPE 3 PITS (Mainline)											
3	19					F B					Watch for fox and bear denning sites
10	26			X							
GM132	39	X				F?					
GM133	39										Parsons Lake lateral. Location uncertain
GM136	43										
GM4	57										
GM138	91										
GM39	91	X									
GM78	120										
GM140	129										Same as GM115?
256	130										
GM96	142							X			
GM116	143										
GM117	199										
303	203										
306	212										
319	231										

[1]Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2]Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3]Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4]Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5]Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6]IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 3 PITS (Mainline - cont.)											
328	276										
FGH7	294										
P315	303										
P319	312	X									
GM118	375										West of Mackenzie River
NW4	378	X		X						X	Within proposed Development Control Zone - Norman Wells
P262	408										
P242	459										
P226	464										
P227	466										
P199	490	X		X							
P197	495										Location uncertain
P191	507										Possible impact reduced if pit farther back from river
GM119	517										West of Mackenzie River
P133	517						X?				Uncertain location
P159	552										
W5	566						X				Within proposed Development Control Zone - Wrigley
P152	574										
P146	580	X									
P139	599										Keep pit and spoil out of lakes
GM120	600										West of Mackenzie River

[1] Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2] Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3] Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4] Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5] Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6] IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 3 PITS (Mainline - cont.)											
P124	620	X	P118								
P118	620	X									
None	658						X?				Avoid stream channel
GM20	670	X									
GM19	671	X									
GM122	690										
GM97	699			X							
GM22	705						X?				Avoid stream channel
GM98	705	X		X							
GM99	707										
GM100	710										
GM101	713										
GM27	717										
GM90	730										
GM123	733										
GM30a	752	X									
GM30	755	X									
GM89	763										
GM143a	817										

[1]Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2]Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3]Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4]Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5]Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6]IBP: International Biological Programme

INVENTORY OF PROPOSED PITS
(continued)

Borrow Pit #	Mileage[1]	Large Pit[2]	Alternate To	Probable Summer[3] Operation	Noise[4]	Habitat[4]	Siltation	Archaeology	Recreation/ Aesthetics	Community Use[5]	Commentary
TYPE 3 PITS (Prudhoe Bay Lateral)											
GM126	244		GM125		R? C		X				Location uncertain - may be a Type 2 pit if raptors
GM35	269	X	133		C						
GM36	314	X	138			F		X			
GM127	348										
141	361	X									
GM37	361	X									
237	432	X									
GM39	432	X	237								
249	473										
252	485					F? B?					Watch for fox and bear denning sites

[1]Mileage: All mileages are expressed as pipeline mileages. Borrow pits not on the right-of-way are assigned approximate pipeline mileages

[2]Large Pits: In excess of 100,000 cu yd to be extracted (inferred by Assessment Group)

[3]Probable Summer Operation: Most pit operations in winter; Assessment Group infers possible summer operation of marked pits

[4]Noise, Habitat: B - Grizzly Bear; C - Caribou; F - Arctic Fox; M - Moose; R - Raptor; S - Dall's Sheep; W - Waterfowl

[5]Community Use: Includes possible granular resource conflicts (*see* topic "Borrow Material Resources")

[6]IBP: International Biological Programme

8.13 CONSTRUCTION OF PIPELINE FACILITIES AND ROADS

Introduction

Pipeline development involves construction of a large number of varied facilities. Within the Northwest Territories and the Yukon, the proposed Canadian Arctic Gas Pipeline requires gas-measuring stations; compressor stations with compressing and chilling units; station and line block valves, each requiring prepared foundations; and side valves with potential sales-measuring stations. The associated radio communication system involves construction of steel towers at about 25-mile intervals, each requiring prepared foundations. Wharves will be built at 12 new sites and 5 existing wharves will be upgraded; stockpile sites will adjoin many of the wharves. Air transport facilities will be supplemented by construction of four 6,000-foot airstrips, eight 2,400-foot airstrips, and by upgrading of three existing community airstrips. Helipads will be built at various compressor stations, communications sites and wharf sites. Although temporary and snow roads will be used extensively, a substantial number of miles of permanent road will also be required.

The airstrips, helicopter pads, stockpile areas and off-loading areas at wharf sites will be simple granular fill pads. At compressor and measurement stations, communications sites and block-valve sites, special footings of pile and/or concrete pad construction will be required within the pad areas. Despite considerable experience with pad construction in the region, only a limited amount of well-documented long-term performance data is available mostly from Inuvik and its adjacent airport. Until recently, pad and road design has been based on arbitrary decision without geotechnical investigation; not uncommonly pad thickness has been inadequate to preserve permafrost, necessitating periodic grading and additional filling over many years as thaw and settlement take place. Pile construction has been used extensively in the region, and is not expected to present special problems in pipeline-related construction. Major airfields have been constructed at Inuvik and Norman Wells by combining careful site selection and appropriate design, and in particular, provision of sufficient fill thickness to retain permafrost. Simple earth airstrips have proved satisfactory at communities such as Fort Norman and Fort Good Hope, where they are built on thaw-stable soil. However, a number of airstrips have been located on ice-rich permafrost and have required frequent filling and grading where fill thickness has been inadequate to preserve the permafrost.

Applicant's Data

The general principles to be followed in design of pads, foundations and roads are described in Section 8.b.1.4.3 (Compressor and Gas Measurement Stations), Section 8.b.1.4.5 (Roads, Airstrips and Helicopter Pads) and Section 8.b.1.3.8.4.1 (Control Measures, Access Roads). Generalized foundation designs appropriate to various site conditions are shown in Drawings No. 1-0500-3002 and 2-0800-7024 (Sect. 8.b.3).

In permafrost soils with high thaw-settlement potential, design will provide for preservation of permafrost. Pads and roads will be designed so that summer thaw will not extend to the base of the fill, either by providing sufficient thickness of selected fill, by inclusion of layers of artificial insulating material, or by installation of cooling or refrigeration ducts within the fill. In permafrost soils with low thaw-settlement potential, foundations will be designed to accommodate minor thaw-settlement, and fill will be stockpiled for levelling pads. In non-permafrost soils

subject to frost heave, pads and roads will be designed to minimize heave.

The Applicant has already developed and tested geothermal analysis techniques for predicting the geothermal regime of soils under stresses imposed by construction of the pipeline and such facilities as pads and roads (Sect. 8.b.1.3.7, Geothermal Analysis), and is currently investigating problems of heave in frost-susceptible soils.

Concerns

1. Information supplied by the Applicant regarding construction of wharves, stockpile sites, roads, airstrips, helicopter pads, communications sites, block valves, measuring stations and compressor stations is less complete than that relating to the pipeline itself and is lacking in details essential to effective assessment of environmental impact. The following inadequacies are particularly notable; some of them have been recorded in "Requests for Supplementary Information".

a) A number of the facilities lie outside the Alignment Sheets and are shown only on smaller scale route maps accompanying Section 13.a.2.2; there are several inconsistencies in locations between the Alignment Sheets and the route maps.

b) Virtually no geotechnical data are provided for compressor and measuring stations and block-valve sites. Neither terrain nor geotechnical data are provided for sites of facilities and interconnecting roads that are not on the Alignment Sheets, nor is there any statement of the principles and criteria that will determine the kind and extent of geotechnical investigations and terrain analysis to be undertaken prior to final design.

c) The principles that will be used in design of pads, foundations and roads are described (Sects. 8.b.1.4.3; 8.b.1.4.5), but no examples are provided to illustrate the application of the principles to specific terrain and climatic conditions. The Applicant's design of pads and foundations for compressor and gas-measurement stations, and for support facilities such as airstrips and helicopter pads will be determined primarily by whether the sites are on "permafrost soils with high thaw-settlement potential" or on "non-permafrost soils and soils with negligible thaw settlement" (Sects. 8.b.1.4.3)
In the former, design will provide for preservation of permafrost conditions in order to prevent settlement; in the latter, there will be no requirement to preserve permafrost but foundations will, as required, be designed to accommodate minor settlement. Additionally, in non-permafrost soils, design will depend upon whether the soils are susceptible to frost heave. However, these statements of principle are not accompanied by any indication of the allowable limits of settlement or heave for the various types of structures, or the kind and extent of investigation that will be undertaken to determine potential for settlement of heave on a site-by-site basis.

d) Only limited information is provided on drainage control and the drainage structures to be used.

2. Although lack of data precludes detailed assessment of the location of compressor and measurement stations and support facilities, it is possible to identify from available data a number of sites where there is significant potential for environmental and/or engineering problems. Many such situations appear to have arisen from rigid adherence to hydraulic requirements of the gas system in spacing compressor sites along the route. Location of support facilities for compressor sites, such as airfields, wharves and connecting roads is in turn determined to a considerable degree by location of

the compressor sites themselves, leading to location of such facilities at sensitive sites. A number of illustrative examples follow.

a) *Drainage:* At compressor station M-04 on the east side of Thunder River, the site as shown on the Alignment Sheets lies astride the confluent drainange from three small lakes and thus presents a drainage problem. The use of extremely long culverts to conduct drainage under large pads is considered to be impractical, and ditching of drainange around pads is inappropriate in ice-rich soils. Pads at compressor stations M-02, M-14 and M-17, and airstrips at CA-07 and CA-09 are also judged to be poorly located with respect to drainage.

b) *Access Roads:* At compressor station M-04, the proposed location for an airstrip is on sand and gravel outwash one mile south of the compressor site. However, because a gully with unstable slopes lies between the airstrip and compressor site, a permanent road between the two must follow a circuitous route 4.7 miles long. Similarly, at compressor station M-12 a permanent road from the site to the proposed Mackenzie Highway must cross the steep walls of a deep valley, probably necessitating grade cuts with potential for slope failure and erosion. Location of the compressor on the west side of the valley would eliminate the valley crossing and reduce the road length by 3/4 mile.

c) *Wharf and Access:* At the proposed wharf site near M-04, bluffs bordering Mackenzie River rise steeply over 300 feet to the upland surface; the permanent road that will provide access to the compressor station and airfield on the upland surface must follow a confined gully, where road construction will require either thick embankment fill or side-hill cuts on potentially unstable colluvial slopes. Only a very restricted area is available at the mouth of the gully for off-loading above the flood level of Mackenzie River without resort to excavation into the toe of a colluvial slope and/or placement of large volumes of fill. Problems of off-loading space and access to the upland are even more acute at the wharf site serving compressor station M-06. There, the problems are exacerbated by the existence of a major landslide scar at the wharf site as shown on the route map (Drawing 1B-0211-1002).

d) *Foundation Conditions:* Compressor stations M-16 and M-17 are located in areas of peatland consisting of elevated peat plateaux interspersed with thawed depressions, and the proposed permanent road between Liard Highway and M-16 crosses numerous areas of the same terrain. The organic soil of the thawed depressions has low bearing capacity and is highly compressible. Major differential settlement of pads and roads can be expected even if pad thickness is adequate to retain permafrost in the peat plateaux.

e) *Borrow Source:* Compressor station CA-09 is situated on the south side of Rat River. The Applicant proposes to extract 1,700,000 cu yd of gravel from the flood plain and low terraces of the river, which is an important fish stream. Location of the compressor station and airstrip north of Rat River would permit exploitation of a very large glaciofluvial gravel deposit north of the river, with minimal environmental risk.

f) *Water Supply:* A number of compressor stations that will serve as construction camps are distant from assured winter water supplies and long haul roads (probably all-weather) will be required from the source of water to the camp. Location of such roads is not shown on Alignment Sheets or route maps, nor are requirements for borrow materials included in the Applicant's estimates.

3. Location of storage tanks for fuel and other liquids such as methanol is of critical concern because of potential for pollution. Floods, ice jams, unstable soils and landslides are judged to be significant hazards to storage tanks at wharf sites such as those serving compressor stations M-04 and M-06, where there is little or no off-loading area above flood level of Mackenzie River, and where immediately adjacent high bluffs are potentially unstable.

4. The Applicant has stated (Sect. 8.b.1.3.8.4.1, p.63) that "many miles of roads have been constructed successfully to date by the Federal Government and industry in permafrost areas. The design and construction techniques are well known and generally require some modification from those of non-permafrost areas." However, experience in construction of Mackenzie Highway continues to show that although principles of location and design in permafrost areas are generally well understood, application of the principles to specific in-field situations is very complex. Thus, although the Applicant's general principles for location and design of permanent roads are considered to be appropriate, probable impact of proposed road construction cannot be assessed until detailed data are provided on location, and soil conditions and proposed design on a mile-by-mile basis.

5. It appears that substantial adjustment and refinement of plans, procedures and locations of facilities and roads will be undertaken by the Applicant as he proceeds with detailed planning and final design. The comments on specific sites recorded in this topic, and in the topics entitled "Environmental Effects of Borrow Operations" and "Pipeline Impact in Valleys" are relevent in this regard. The Assessment Group considers that a further review of plans for construction of facilities and roads would be appropriate at the final design stage.

Highlights

1. The pipeline project will involve a large number of varied facilities in addition to the pipeline *per se*. This paper deals with location, foundation and related facets of these facilities.

2. The Applicant's proposals for most of these facilities are lacking in detail and are less well defined than the information provided for the pipeline itself. A number of facilities lie outside the areas covered by the Applicant's Alignment Sheets. The information provided does not permit an adequate assessment of potential impacts.

3. On the other hand, potential environmental and engineering problems are apparent at a number of sites. Several sites of this nature are discussed in the paragraphs headed "Concerns".

4. Location of fuel storage tanks relative to potential landslides, floods, ice jams and unstable soils deserves particular attention.

5. Little specific information has been provided on procedures for road construction drainage, etc. Standard environmental and engineering procedures now being used for the Mackenzie Highway appear to be appropriate also for the Applicant's permanent roads.

6. The Applicant will undoubtedly have to make substantial adjustment and refinement of his plans, procedures and locations for his various facilities as he proceeds with final design. A further general assessment by government of such revised plans would be appropriate at the final design stage.

8.14 REVEGETATION

Introduction

It is the expected practice in this day and age to tidy up after construction, particularly in wilderness or rural areas. Surplus materials and debris are removed, and where the vegetation has been removed and soil excavations made, appreciable effort is devoted to rehabilitating the disturbed landscape so that the new scene is as aesthetically acceptable as possible.

The development of the Mackenzie Valley gas pipeline with its ancillary facilities is no exception in this regard. But in this case the rehabilitation measures have to be effected for more than aesthetic reasons, important though these are. In the northern areas the vegetative cover, together with its underlying organic mat and more extensive network of roots, plays a vital role in terrain stability. In permafrost areas, removal of the plant cover and the organic mat can change the soil-thermal regime, thereby increasing the thickness of the thawed or active layer in summer and causing permafrost regression or degradation. In sensitive permafrost areas, where the soils are fine textured and ice rich, this additional thawing leads to a variety of instability problems, such as subsidence and slumping. Outside permafrost areas the plant cover prevents wind erosion and various forms of water erosion, such as sheet-, rill- and gully-erosion. Both in permafrost and non-permafrost areas, therefore, the removal of a plant cover can start processes that could threaten the stability of facilities and cause environmental damage, such as impeded drainage and silted watercourses.

It is not surprising, therefore, that the Applicant devotes considerable attention to measures designed to re-establish a vegetative cover where his construction activities will disturb or expose the soil. In the Yukon and Northwest Territories the areas so affected include the entire 1,200-mile length of the pipeline right-of-way, some haul roads, borrow pits and the surrounds of certain ancillary facilities. As might be expected the degree of disturbance depends on the type of construction activity. For the right-of-way, for example, all trees and larger shrubs will be removed over the entire 120-foot width. This affects all areas south of approximately Inuvik. Where Arctic construction is used the aim is to disturb only the central 12- to 15-foot-wide ditchline, hence it is largely this which has to be revegetated. Where conventional construction is used it is the entire 120-foot width, for the entire width is graded.

The Applicant states he "...has established a program which is designed to restore the terrain to its previous condition and to ensure that environmental stability has been re-established" (Sect. 13.a.6.8, p.57). Revegetation plays a core role in this proposed program. It has been necessary to prepare several "Requests for Supplementary Information" (#30, 31, 32, 33, 34) in respect of the program described, but on the basis of the information available, the Assessment Group elaborates its concerns below. It is recognized that revegetation is an essential but challenging task that embodies numerous technical difficulties. At the same time, the Applicant seems to rely too much on seeded grasses as the means to re-establish a sufficiently protective and insulative vegetative cover. The Assessment Group considers that more varied and elaborate revegetation measures will be needed; these could be developed and tested for the final design stage.

Applicant's Data

Background

The Applicant has described the techniques he has developed to revegetate areas disturbed during the construction and operation phases of pipeline development. These techniques are intended to be applied to all areas where plant growth is feasible and their objectives, as expressed in Section 13.a.6.8, p.57, are:

> A major purpose of the Applicant's restoration and revegetation program in all areas of the system is to establish equilibrium conditions whereby thermal or hydraulic erosion, ditch settlement, slope instability and any other type of degradation is eliminated or reduced. Such measures will meet two complementary objectives, namely:
> a) establishment of acceptable environmental conditions; and
> b) maintenance of the integrity of the operating pipeline.

The Applicant expects the revegetation program to restore a favourable soil heat-balance by providing an insulating cover (Sects. 8.b.1.3.8.4.2; 14.d.N.2.1.3; 13.b.5.4.1), to provide—along with mechanical means—drainage and erosion control (Sects. 8.b.1.3.8; 13.b.5.4.1; 14.d.N.2.1.7), to promote slope stability (Sects. 8.b.1.3.8.4; 14.d.N.3.6), to restore lost habitat (Sect. 14.d.N.2.2.3; 14.d.N.7.8.1, and elsewhere), and to improve the aesthetics of the facility (Sect. 14.d.N.2.1.5).

The proposed revegetation program was developed partly from a literature review, partly from consultation, and partly from special field experiments set up at Prudhoe Bay, Sans Sault, and Norman Wells. Revegetation of larger disturbed areas, such as well sites, has also been tried but the results are not included in the Application (Sect. 13.a.6.8). Revegetation trials were also set up at Inuvik and Tuktoyaktuk (Sect. 14.d.N.3.6).

The revegetation studies are summarized in Sect. 14.d.N.3.6, discussed briefly in Sect. 8.b.1.3.5, and described in detail for the Sans Sault test site in Volume Two, Biological Report Series. From these studies the Applicant has "...determine(d) methods and species best suited to revegetate the right-of-way in the various physiographic regions along the route" (Sect. 14.d.N.2.2.1).

Revegetation specifications appear on the Alignment Sheets and are discussed briefly in Sect. 8.b.1.3.8.4.1. They are not complete, however, as they apply only to the pipeline segment from 60°N. to the Travaillant Lake junction (Section 1B on the Alignment Sheets). The revegetation procedures developed from the above are described in detail in Sect. 13.a.6.8, Restoration and Revegetation, Sect. 8.b.1.3.8, Terrain Stability, and throughout Sect. 14.d.N (14.d.N.2.1.3; 14.d.N.2.1.6; 14.d.N.2.2.1, and elsewhere).

The construction procedures described (Sect. 13.a.6) are of two types, so-called "conventional" and "Arctic". The latter is a modification of conventional winter construction and is considered appropriate for sensitive permafrost areas (Sect. 13.a.6.1, p.27). Summarized below are the revegetation procedures where conventional winter construction will be used. Modification of these procedures required for Arctic construction are noted.

The Applicant proposes to revegetate all areas disturbed during construction and operation of the pipeline (Sect. 14.d.N.2.2.1, p.8). Specifically mentioned is the right-of-way, borrow pits, the perimeters of gravel pads, and temporary access roads (Sect. 13.a.6.4.2; 13.a.6.8). He states: "The primary means of re-establishing plant cover on exposed soil will be the application of seed and fertlizer. Other methods to be used on less extensive segments of the route include the

stripping and replacing of the organic mat in tundra areas, hand planting of shrub cuttings on side slopes and the laying of pre seeded soil binding mats" (Sect. 8.b.1.3.8.4.1, p.61).

The right-of-way will be seeded in the spring following construction with a mixture of native and agronomic grasses (Sect. 8.b.1.3.8.4.1 and Alignment Sheets) using fixed-wing aircraft and helicopters. Fertilizer containing nitrogen, phosphorus, and potassium will be applied with the seed at a rate of 350 lb/acre (Sect. 14.d.N.7.7.2, p.28). For areas where Arctic construction has been applied, special seed mixtures will be used but the composition of these mixes is not given.

The revegetation of borrow pits is described in Sects. 13.a.6.8 and 14.d.N.2.2.1. Organic material and "top soil"—stripped and piled separately during the development of a pit—will be spread back over the pit surface, graded and contoured to eliminate sharp relief, re-seeded, and fertilized. Seeding and fertilizer specifications are not given. Special restoration measures to assist in the establishment of natural lake regimes are proposed for those borrow areas that have infilled with water.

Slopes on the right-of-way require different techniques because the problems of erosion and terrain instability are potentially more severe than on the more level segments. Ground crews will spread erosion-control mats, plant shrub cuttings, and hand seed the grass mixtures. Specifications are given in Sect. 8.b.1.3.8.4.1 and on the Alignment Sheets.

In permafrost areas where cuts are required, artificial insulation may be necessary to prevent thaw and subsequent slope instability. The Applicant suggests that for small areas pre-seeded soil-binding mats of a rockwool base may be adequate, but that for larger areas sheets of foam will be placed and covered with six inches of gravel and top soil. This cover fill will hold the foam in place and "...provide adequate growth conditions for the revegetation" (Sect. 8.b.1.3.8.4.2, p.70).

The cleared areas along the margins of gravel pads, whether for compressor stations or otherwise, will be revegetated. Temporary access roads will also be revegetated (Sect. 13.a.6.4.2, p.33). Specific details are not given.

In many tundra areas (to be identified on Alignment Sheets when final location is fixed), it is proposed to remove the existing organic mat from the ditchline, to stockpile it and to replace it, following construction, over the surface of the backfill crown or berm. This is to be a means of re-establishing native vegetative cover (Sects. 13.a.6.5.10; 13.a.6.8). The methods are outlined in Section 13.a.6.5.4 but detailed specifications have yet to be developed (Sect. 13.a.4.1). Experimental studies at Sans Sault (Sect. 8.b.1.3.5) have shown that removal of the organic layer in sod form was difficult. Studies at Prudhoe Bay have indicated that revegetation using agronomic grasses was inhibited where organic layer replacement was tried. The grass species tested grew better in mineral soils.

Natural revegetation is mentioned by the Applicant in Sects. 13.a.6.8 and 14.d.N.2.2.1. Recolonization by native plants is to be encouraged by the Applicant.

Revegetation may be required during the operation and maintenance of the pipeline to restore the vegetative cover to areas disturbed by erosion and slope instability, settlement and compaction of the ditch crown, and repairs to the line (Sect. 13.b.5.4.1, p.22). These restoration and revegetation procedures will be similar to those used

during the construction phase but may be modified if certain mixtures of grasses prove superior under particular environmental conditions (Sects. 13.b.6.1.4,13.b.5.4.1). Light maintenance fertilization will be required during the second or third spring following seeding to ensure the continued healthy growth of the seeded grasses.

Concerns

Insulating Effects of Vegetation

The Applicant states: "The data from the Applicant's test site at Sans Sault indicate that, two years after construction disturbance, a plant cover can be restored which will provide insulative protection over a pipeline within a northern boreal forest" and that "The combination of a chilled pipeline and a plant cover will return the permafrost table to the pre construction level in one to three years. As this represents a re-establishment of soil thermal conditions to a near natural state, the effect of the pipeline on this important ecological factor will not be detrimental" (Sect. 14.d.N.7.6, p.13).

These and related statements (Sects. 8.b.1.3.8.4.2, p.70; 13.b.5.4.1, p.22) do not seem to be supported by the Applicant's own data as presented by Dabbs *et al.* (1974) and are at variance with the conclusions of a number of recent investigators (Strang, 1973; Zoltai and Pettapiece, 1973; Zoltai and Tarnocai, 1974).

The presence of permafrost along the proposed pipeline route depends on a changing complex of environmental factors—including climate and vegetation—whose roles change in importance (Brown and Péwé, 1974). Haag (1973) noted that in the boreal forest the potential for long-term damage increases with the complexity of the vegetation and that the greatest change in the soil-energy budget occurs in those communities with the most stratified canopies. Judge (1973), in his examination of the thermal regime of the Mackenzie Valley, found that from 61°N. to 66°N. much of the permafrost is at a temperature where only a small heat-input could change the ice-water content of the soils considerably. Indeed; "...the mere act of removing the surface vegetation seems to be sufficient to change the mean surface temperature by several degrees". Linell (1974), in tests conducted at Fairbanks, Alaska, found that, following the removal of tree cover, without disturbance to the surface vegetation and organic layer, the permafrost table was lowered 2.5 meters in ten years. Kurfurst (1973) noted a lowering of the permafrost table following tree removal at Norman Wells, N.W.T.

The Applicant's revegetation program of field tests had several objectives (Williams Bros., 1972), one of which was to assess each seeded grass species as producers of accumulated decomposed and undecomposed organic material on the soil surface. The role of accumulated organic matter, especially moss and peat, in protecting the permafrost from insolation is well documented in the literature (Brown and Péwé, 1974), but in his tests, the Applicant does not appear to have selected the more critical parameters. Thus, litter-accumulation rates were measured only as a percentage of the ground surface covered (Dabbs *et al.*, 1974), and the thickness of the accumulated layer was not measured. More useful parameters would have been the rate of accumulation, the thickness of accumulated organic layer when the rate of deposition equalled the rate of decay, and the termal characteristics of the accumulated material. A forecast might have been made of where, along the pipeline right-of-way (in the northern boreal forest), one would expect this layer of accumulated organic material to promote the re-establishment of the pre-disturbance

permafrost level.

Little information is available on the rates of accumulation of organic matter under northern grasslands. It could be that the results obtained from more southerly conditions might apply. Daubenmire (1959), for example, has noted that in grasslands litter decays rather quickly and completely so that at any one time there is very little material representing stages of decay between dead grass leaves and humus. Results reported by Haag and Bliss (1974) for test plots near Tuktoyaktuk point to the same conclusion, for they found very little litter had been produced where re-seeding had been done three years previously. However, at this time conclusions about litter accumulation under seeded agronomic grasses and its effect on permafrost would be premature.

Soil-heat flows were also measured by the Applicant to evaluate quantitatively the effect of revegetation with grasses on the soil-energy budget. The results are presented by Dabbs *et al.*, (1974). One-year averages for soil-heat flow. estimated by fitting a truncated series of data to a sine curve, show that for all recorded plots, including the undisturbed spruce forest plot, there is a net flow of heat into the ground. It is concluded by the Applicant that 1972 was a "warm year" (Dabbs *et al.*, 1974). However, when the results are "...adjusted to a balanced condition (0.0 heat flow in the undisturbed site)" the revegetated plots still showed a net yearly inflow of heat into the ground. These results may not be atypical of northern grasslands. Kalio and Reiger (1969) found that at Fairbanks, Alaska, the active layer under perennial grasses thickened to five metres from one metre (in 3 yrs) and Brown (1965) recorded summer soil temperatures at Norman Wells under native and seeded grasses that were near ambient air-temperatures. Hernandez (1973) has noted that in the tundra immediate (one to three years) restoration of the natural soil-energy budget does not appear possible by re-seeding alone. These considerations suggest the Applicant's results do not lead one to believe that seeded grasses can quickly restore permafrost levels to their pre-disturbance state.

The long-term effects are less clear. The accumulation of organic matter following its removal by fire or other type of disturbance is a very slow process. Zoltai and Tarnocai (1974) found that, following fire, the permafrost table in hummocky terrain began to rise 60 to 80 years after the *establishment of trees*, attained its pre-disturbance level by 100 years, but that the organic layer did not develop its pre-disturbance thickness for at least 150 years . Zoltai and Pettapiece (1973) had previously estimated that following disturbances, such as fire, several vegetational cycles of about 150 years each were required to restore the full organic mat. Cody (1964, 1965), Strang (1973), Viereck (1973), and Wein (1974) have reached similar conclusions for various northern localities. Thus, the limited information available suggests that rates of vegetation succession are slow and variable as are those for organic matter accumulation.

Attempts to predict either the course or rate of vegetational succession are hindered by the general lack of quantitative information, the varied environmental situations along the route of the proposed pipeline, and by the Applicant's proposal to keep the shrub layer along the pipeline right-of-way cut back (Sect. 14.d.N.7.6, p.16). The process of succession will be arrested in its early stages and one can only speculate as to how species composition will change and what the stable (or ultimate) vegetation will be under these quasi-equilibrium conditions. A permanent grassland, especially in the boreal forest, may result.

Following the clearing of trees from his test site at Fairbanks, Linell (1974) found that a dense growth of grasses, shrubs, fireweed, and low brush shoots (including willow, alder and dwarf birch) developed and added to the original ground cover. Viereck (1973) noted that forested areas in the lower elevations of the Alaska taiga (sub-arctic forest), if repeatedly burned, sometimes developed into meadowlands dominated by *Calamagrostis canadensis*, *Rosa acicularis*, *Carex* spp., and many herbaceous species. Gill (1973) found that some areas of the Mackenzie Delta reverted to treeless tundras when cleared of their tree cover.

Many species of bryophytes were found to establish themselves naturally on the mineral soil of the pipeline berm at the Sans Sault test site (Dabbs *et al.*, 1974). This has been attributed to the enhanced growth conditions afforded by the seeded agronomic grasses. However, if one examines the normal habitats of some of the most commonly occurring species, e.g. *Certatodon purpureus, Leptobryum pyriformys, Funaria hygrometrica,* and *Marchantia polymorpha*, it is found that they commonly occur as pioneer species on raw or sterile mineral soils (Conard, 1956; Shofield, 1969). Also Rowe and Scotter (1969), Viereck (1973), Wein (1974), and other workers have recorded that *Ceratodon Purpureus, Polytrichum juniperiumm,* and *Marchantia polymorpha*, are common pioneer byohpytes following disturbance. The presence of bryophytes on the test plots does not, therefore, depend on the presence of the grasses, and, in fact, could well be weakened by them.

Little organic-matter accumulation is expected from these pioneer mosses and liverworts because of their growth habit. Wein (1974) found no litter accumulation under *Polytrichum juniperinum* and *Ceratodon purpureus* five years after a fire. Viereck (1973) found that the pioneer mosses and the liverwort *Manchantia polymorpha* may dominate the moss layer for many years.

Seeded agronomic species are not expected to effect an immediate restoration of the natural (pre-disturbance) soil-energy budget in tundra areas (Hernandez, 1973). The Applicant proposes, as an alternative solution, to strip and replace the organic mat (Sect. 13.a.6.5.4, p.41) in the expectation that the insulating qualities of the replaced organic material will reduce the rate of permafrost recession (Sect. 14.d.N.7.6, p.13 and Dabbs *et al.*, 1974). The supportive documentation seems inadequate and has been the subject of "Requests for Supplementary Information" (#40). The information from the Prudhoe Bay test facility also appears insufficient. In Sect. 8.6.1.3.5.2, p.23 it is stated "At Prudhoe Bay the wet sedge peat surface layer was used to cover backfill. The insulating qualities were demonstrated to be better than other types of fill..." and in Section 8.b.1.3.5.3, p.27 "Types of materials used in ditch fill and grade construction consisted of gravel, mixed soil materials from the ditch excavation, surface peat from an experimental borrow pit, and mixed soil materials covered with gravel." As there seems to be no mention of tundra removal and replacement over a backfill mound, one wonders whether the results reported are incomplete or have been misinterpreted.

However, even if replacement of the stripped organic material over the backfill mound can be demonstrated to be an effective insulating technique, the Applicant does not propose to apply it to all tundra sections of the right-of-way. Here no alternative measures, natural or engineering, are proposed to prevent permafrost recession.

It is apparent from a consideration of the above that revegetation by the procedures described will not prevent short-term permafrost recession and, contrary to the Applicant's statement that the effects of the pipeline on the permafrost level will not be detrimental, the permafrost will,

in fact, recede along many sections of the pipeline right-of-way (Sect. 14.d.N.7.6, p.13).

The effects of the disturbance on the natural soil-energy balance will vary along the pipeline route but are expected to be most severe where small-scale earth hummocks occur under mature spruce-lichen forest (Zoltai and Tarnocai, 1974). As the ice in the permafrost near the surface melts large quantities of water will be released, and slope instability ensue. The consequences of such slope instability have been discussed elsewhere (*see* topics "Vegetation Clearing", "Slope Stability" and Erosion Susceptibility"). Generally, subsidence of up to one metre will occur on gentle slopes. In tundra areas, where the permafrost is in equilibrium with a discontinuous and thin organic cover, *minor* disturbances are less likely to initiate rapid permafrost recession.

Solutions to the problem of permafrost recession other than revegetation alone are required if both the integrity of the pipeline is to be assured and the environmental degredation minimized.

Terrain Stability

An integral and important part of the proposed erosion-control procedures (Sect. 8.b.1.3.8.4) is revegetation of the disturbed areas with selected grasses and, in some instances, with seeded erosion-control mats and shrub cuttings. Such procedures can provide both short- and long-term protection from erosion, a particularly important consideration where the quality of waterbodies must be maintained (*see* "Suspended Sediment"). The Applicant expects that the seeded vegetation will provide a stabilized cover to the ground surface (Sect. 8.b.1.3.8.1), and the value of such a cover to prevent sheet, rill, and gully erosion is well documented (Buckman and Brady, 1969). A dense stand of vegetation can intercept rainfall and nullify the dispersing impact of raindrops. It contributes organic matter that becomes incorporated into the surface soil giving greater aggregate stability and absorptive capacity, and the plant roots help to hold the soil in place even when runoff is appreciable. If grasses are to be used as vegetation, then the kind of grasses, their planting density, and vigour all greatly affect the resistance to erosion. However, it is not apparent how the Applicant has used the data provided by Dabbs *et al.* (1974) for the selection of grass species and the rooting characteristics of the different species seems only to have had a perfunctory assessment. There is some doubt, therefore, that rooting characteristics were considered when species where chosen. Those selected may well be the best available but confirmatory documentation is lacking.

The Applicant expects also that the seeded vegetation will provide an insulative cover capable of preventing permafrost recession. The validity of this assumption has been questioned above. Where terrain subsidence, through loss of volume from ice melt, accompanies permafrost recession, erosion of exposed mineral soil is likely, especially on slopes which become unstable. The consequences of this are discussed elsewhere. Under such conditions of soil instability revegetation is likely to be unsuccessful and cannot be expected to prevent erosion. On more gentle slopes subsidence may not lead to slumping but it could interfere with natural drainage patterns. A concentration of flow may result with erosion occurring along the ditchline. This would jeopardize the integrity of the pipeline and cause other environmental damage.

The erodibility of soils depends on several factors, an important one of which is water velocity. For example, doubling the velocity of flow increases

the weight of particle that can be carried by a factor of 64, increases the amount of suspended sediments 32 times, and increases the erosive capacity of the water flow 4 times. Although a sod formed from a good growth of grasses will provide efficient protection against sheet and rill erosion, it will not—either in the short- or long-term—provide sufficient protection on long slopes or from concentrated flows where the erosion force is greater. Therefore, the erosion-control structures proposed by the Applicant should shorten slope length, reduce flow velocities, and avoid concentrating flows. It is not clear that they can do this because they are acknowledged to be somewhat experimental (Sects. 8.b.1.3.8.1; 8.b.1.3.8.4.1, p.65; and 14.d. N.6.2). This is discussed at greater length elsewhere (*see* topic "Drainage and Erosion Control").

So much for concerns centring on the expected achievements of the revegetation proposals; attention is now focused on the techniques themselves.

Incompleteness of Information

For all sections of the proposed pipeline, the Applicant has provided a revegetation coding which is shown on the Alignment Sheets. The coding for pipeline section 1B differs from that for the remaining sections. Revegetation specifications based primarily on experimental work conducted at Sans Sault, N.W.T. (Dabbs, *et al.*, 1974) are given in Section 8.b.1.3.8.4.1 and apply only to pipeline section 1B (Travaillant Lake junction to 60^{O}N.). No revegetation specifications have been given for the remaining sections and the omission has been included in "Requests for Supplementary Information" (#39). This omission raises the general concern that the unspecified procedures cannot be fully evaluated, beyond general comments about tundra removal and replacement.

Tundra Removal and Replacement

In some tundra sections the Applicant proposes, before ditching, to strip the organic layer mechanically, then to replace it on the ditch berm after filling in the ditch (Sect. 13.a.6.5.4). In this way it is expected that the native vegetation will be quickly re-established (Sect. 14.d.N.2. 1.6) and an insulative cover provided (Sect. 14.d. N.7.6). The final locations for the application of this procedure have not been determined (Sect. 13.a.6.5.4) and there is concern about its effectiveness.

The rapidity and pattern of re-establishment of native vegetation following disturbance is uncertain. The regeneration of tussock tundra disturbed during a winter seismic operation (Dabbs, *et al.*, 1974) is very different from the replacement of highly disturbed plant parts, living and dead, over an elevated berm of sterile mineral-soil. Most bryophytes will not survive and their replacement will only add to the organic layer and not promote the re-establishment of bryophyte species. Some root stocks of vascular species, especially dwarf willows and birches, will probably remain viable and sprout the summer following construction. Their survival through the subsequent winter, however, is less certain. In their natural habitat these shrubs occur in the hollows between hummocks and during the winter are buried under snow. This protects them from extremes of cold, from the abrasive effects of wind-blown snow and ice particles, and from the desiccating effects of wind. Vegetation on the exposed flanks and crown of an elevated berm would receive no such protection. Wind erosion of the berm can also be expected along the Yukon coastal plain, which, if uncontrolled, could inhibit the establishment of any vegetation, exotic or native.

There is concern that the Applicant has not

considered fully enough such special problems in formulating his revegetation procedures for tundra sections of the pipeline.

The following concerns centre specifically on Pipeline Section 1B for which the Applicant has provided revegetation specifications and supportive documentation. They apply in a general way, too, to revegetation procedures proposed for the remaining sections of the pipeline.

Selection of Grass Species

The revegetation specifications proposed were developed from the Applicant's field experiments conducted at Sans Sault (Dabbs *et al.*, 1974). From previous considerations it appears that the primary role of any post-disturbance revegetation procedure should be the prevention of soil erosion. This is especially so where the quality of aquatic ecosystems could be adversely affected or the integrity of the pipeline jeopardized. Concern arises because the species selected by the Applicant may not be the most suitable for this purpose. His selection of species and procedures has been predicated by the need to prove that the species will provide insulation and promote a rapid restoration of pre-disturbance soil thermal conditions (Sect. 14.d.N.7.6; Williams Bros., 1972). The vegetative characteristics, beyond survival, that are important in the control of erosion, such as rooting characteristics and growth habit, have received little attention. While the species chosen may, in fact, be the best for the control of erosion, this is not certain from the documentation supplied with the application.

Performance of Seed Mixtures

Except for Climax Timothy, the agronomic grass species chosen by the Applicant for inclusion in the specified seed mixes have been selected on the basis of their performance in pure stands (Dabbs *et al.*, 1974). Although it is indicated that revegetation projects over disturbed areas such as well sites have been carried out (Sect. 13.a. 6.8) no information has been provided on the tests and their outcome. The ability of the proposed seed mixtures to accomplish their desired purpose, therefore, is not clear. But a series of revegetation trials carried out over a representative range of the environmental conditions encountered along the pipeline right-of-way could provide the evidence on which sound practices might be based.

Revegetation procedures developed primarily from tests conducted at one site but extrapolated to the range of sites encountered along Pipeline Section 1B must also be viewed with caution. It is said that grass species have been selected taking into account the physiographic regions crossed (Sect. 14.d.N.2.2.1), the ground conditions encountered (Sect. 8.b.1.3.8.4.1), and the construction methods to be employed (Sect. 13.a.6.8). However, an examination of the revegetation specifications for pipeline sector 1B (Sect. 8.b.1.3.8.4.1 and Alignment Sheets) shows that:

(i) four physiographic regions (Bostock, 1967) are crossed without modification of the proposed seed mixes;

(ii) there is no apparent relationship between seed mix, ground conditions, and terrain units ("Requests for Supplementary Information", #38);

(iii) the Applicant's proposed division between conventional and special Arctic construction modes occurs within section 1B without any apparent change in seed-mix specifications.

Aircraft Seeding

The use of fixed-wing aircraft and helicopters in the aerial application of grass seed and fertilizer is also a concern. Differences among grass species in seed size and weight, direction and speed of wind, and aircraft altitude can cause a highly variable distribution of the seed mix along the right-of-way. Although such variability may not be important along those pipeline sections where the effects of revegetation are largely cosmetic, it is important where erosion is a problem and the establishment of a vigorous grass stand is required. lere, seeding by ground crews should be considered as the preferred alternative.

Application rates of aerially applied fertilizer can also vary widely from the intended rate of ipplication (Armson, 1972). Application rates nuch above the intended rate may have a detrimental effect on the feather mosses. Gagnon (1972) nas found that fertilizer application rates in excess of 100 lb/acre of elemental nitrogen are ethal to the feather mosses, *Calliergon schereberi*, *lypnum cristacastrensis*, and *Hylocomium splendens*. Although survival of the feather mosses following clearing of the right-of-way is doubtful and is ot likely to be affected either way by fertilizer pplication, it is important that the feather moses of the adjacent undisturbed forest stands not e affected. An alteration of the understorey vegeation through the death of feather mosses resulting rom too high a rate of fertilizer application is n unnecessary extension of disturbance beyond the imits of the right-of-way.

ime of Seeding

pring may not be the most appropriate time to eed all intervals of Pipeline Section 1B. The ackfill and berm may settle and compact and in ome places it is expected (Sect. 13.b.5.4.1) that re-seeding may be required during the fall of the first construction year. If such segments could be delineated during the construction phase, (on the basis of the soils information recorded during construction (Sect. 13.b.6.1.2)) such areas could be omitted during the initial spring seeding. This would reduce some of the problems related to fertilizer application rates and limit the unnecessary introduction of exotic grass species into natural (native) vegetation.

Slope Stabilization Using Shrub Cuttings

There is concern that the revegetation procedures (erosion-control mats pegged down with shrubs and seed mixtures applied) proposed to stabilize slopes may not be as effective as expected. As discussed above, the revegetation procedures will probably not provide an immediate restoration of pre-disturbance soil thermal conditions, and where permafrost degradation results in the release of large quantities of water, slope instability will occur. Other methods are required, that prevent soil erosion and promote terrain stability.

The extrapolation of the results from the short-term field tests at Sans Sault to approximately 23 miles of slopes (Code 2-V-6, Section 1B of the Alignment Sheets) appears risky when the differences in materials, natural stability, slope, exposure, and drainage conditions encountered along the route of the pipeline are taken into account. More experimentation is required to evaluate the procedure over the variety of conditions encountered, these conditions especially in regard to which erosion-control mat might be the most effective. This concern again underlines the need for all proposed erosion-control procedures to be well researched and tested before application, because the task is not easy and the consequence of failure could be environmental damage.

Soil Compaction

If serious soil compaction occurs, such as along the right-of-way adjacent to the pipeline trench or along temporary access roads in conventional winter-construction areas, then revegetation may not be entirely successful (Goff, 1971). Some form of soil preparation, such as scarification, will be required. This problem has not been considered.

Inhibition of Establishment of Native Species

Along many sections of the pipeline it can be anticipated that the prime purpose of revegetation will be a cosmetic one to restore aesthetic values. However, a healthy stand of seeded agronomic grasses could inhibit the re-establishment of native vegetation. In such situations, especially native species of vegetation should take precedence over introduced ones.

Highlights

1. Revegetation is carried out where construction activities have occurred and the soil has been disturbed or exposed. Its purpose is to prevent erosion, to restore aesthetic values, or to maintain permafrost and terrain stability. Areas affected include borrow pits and access roads, but are primarily the right-of-way itself. For segments of the pipeline route where arctic construction is to be used, this is mostly the 12- to 15-foot-wide ditchline, but where construction is conventional it is the entire right-of-way width of 120 feet. Revegetation is to be mainly accomplished using seed of various grass species assisted by fertilizers, but other methods, including tundra- and soil-binding mats and cuttings of shrubs, will be applied less extensively.

2. For many permafrost areas the Assessment Group considers that the main revegetation method proposed—the seeding of grasses—will be unable to prevent permafrost regression. On the right-of-way itself, this could be especially so along each side of the ditchline beyond the stabilizing influence of gas chilling. The problem would be most acute on high ice-content soil, where permafrost regression would cause subsidence, possibly threatening the integrity of the pipeline, and leading to environmental problems. One solution is the use of revegetation methods that also embody restoration of an adequate insulating organic layer or other surface mat.

3. The Assessment Group considers that the problem of revegetating slopes successfully has been under-estimated. For thaw-stable slopes and others outside permafrost areas, the vegetation together with its underlying root system prevents sheet erosion and ensuing stream siltation, hence its restoration is critical. On thaw-unstable slopes, erosion-control mats or other measures are also needed. Apparently the Applicant has underestimated the number of slopes requiring this additional treatment, as well as the need for hand seeding and for select seed mixtures suited to the different soil and climatic conditions along the pipeline route.

4. In selecting grass species it will be important to test seed mixtures rather than single species, to measure soil-binding capability rather than top growth, and to evaluate performance over the range of soil and climate that will be encountered.

5. Although aerial seeding and fertilizing are well known techniques, their shortcomings for small areas crossed by watercourses and for seed mixtures made up of different seed sizes do not seem to be recognized, quite aside from the difficulty of getting an intended dosage of fertilizer

uniformly applied. In contrast, revegetation by means of on-the-ground techniques could yield more reliable results and particularly would be more appropriate on critical areas where a failure to obtain a good vegetative cover during the first summer could have unfortunate consequences.

. The technique for revegetation with willow nd alder cuttings, which the Applicant proposes or 23 miles of right-of-way, has been tested at nly one experimental site. Further field tests n the area of proposed use would be appropriate efore completion of final design.

. Removal and replacement of the so-called undra mat is proposed by the Applicant to restore he former soil-thermal regime in order to avoid roblems connected with permafrost regression. nfortunately, the efficacy of the proposed echnique is at present unknown. By the final esign stage, it would be helpful to know where he technique will be applied and how reliable t is.

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8.15 FIRE

Introduction

The well-known destructiveness and uncontrollability of fire has prompted man to go to considerable lengths to devise precautions and procedures that might lessen its devastating and costly effects. The gamut of protection arrangements for forests, public buildings and facilities, and for industrial complexes in Canada are visible evidence of this concern. At the same time, it is important to recognize that fire is by no means solely a menace and not always a man-made one. It occupies an important place in various agrarian and forestry cultural systems and has come to be recognized as a normal and natural component of the boreal forest environment. In other words, the northern Canadian scene of plants and animals would not appear as such were it not for the periodic intrusion of fires started mostly by summer lightning (Heinselman, 1970). This is not to say that natural fires in the Mackenzie Valley are frequent —in fact, on an over-all Canadian scale they are of only "moderate" frequency (Simard, 1973)—but they are frequent enough in historical terms to explain forest regeneration and to account for the complex and changing mosaics of vegetation that occur on different types of terrain.

It follows, therefore, that in our concern for fire and for the possible environmental implications of pipeline development in this regard, it is important to consider not only the possible effects of pipeline activities, but also the reverse pathway; that is, the possible effects of fire on the pipeline facilities, for these, in turn, could trigger secondary environmental effects. Perhaps more than any other topic, fire sits at the nub of a dynamic network that gives reversibility to the normally somewhat rigid concept of impacting- and impacted-variables.

The Applicant has recognized, in essence, the two broad ways in which fires can arise. The effects of pipeline-initiated fires upon the vegetation (Sect. 14.d.N.7.6), siltation (Sect. 14.d.N.7.7.1) and furbearers (Sect. 14.d.N.7.9.7) are considered, and there is the converse consideration of the effects of outside fires upon the pipeline system (Sects. 14.d.N.6.3.2, p.8; 13.b.6.3.1, p.33).

The Assessment Group recognizes that the Applicant has described measures and consultive arrangements with the appropriate regulatory agencies to prevent and control fires, but is of the viewpoint that insufficient recognition has been given to the increased likelihood of fires generated by the presence of construction crews. In addition, the deleterious effects of fires upon terrain stability and the integrity of the pipeline seem insufficiently stressed. Both these factors could combine to generate contingency plans that appear not as strong as the circumstances suggest.

Applicant's Data

The Applicant recognizes the detrimental consequences of fire and has proposed procedures to prevent, detect, and suppress fires during both the construction and the operations and maintenance phases of pipeline development.

Construction Phase

All construction personnel will be trained in fire prevention and fire fighting (Sects. 14.d.N. 7.7; 14.d.N.5.3.3) as part of their environmental education (Sect. 14.d.N.6.1). Fire-fighting equipment will be available at all times (Sect. 14.d.N.5.3.3) and contingency plans developed in collaboration with appropriate government personnel (Sect. 14.d.N.2.2.7; 14.d.N.5.3.3). The

Applicant does not expect an increase in the incidence of fire during the construction phase because "Forest and tundra fires are unlikely during winter construction activities." (Sect. 14.d.N.6.3.2). Special fire precautions will be developed for these times (Sect. 13.a.6.5.5). The incidence of fire during summer construction operation is not discussed.

Operations and Maintenance Phase

Fire detection and fire-fighting procedures to be employed during the operations and maintenance phase are detailed in Section 13.b.6.3. The Applicant indicates that gas-industry standards for fire safety (Sect. 13.b.6.3.1) will be complied with, that all employees will be trained in fire-fighting (Sect. 13.b.2.3), and that practices and procedures (Sect. 13.b.6.3.1) for the prevention and control of fire will be developed in consultation with appropriate government personnel. In sparsely populated areas early detection of fires and the prompt mobilization of fire-fighting forces will be aided by the Applicant's presence and by his extensive communications system. Also contributing will be the Applicant's periodic patrolling of the pipeline right-of-way.

Fire detection and fire control in the unmanned compressor and metering stations will be automatic. Fire here would be detected by photo-electric sensors and heat-rise detectors, an emergency shut-down system would isolate the station from the rest of the pipeline, and the fire would be extinguished by flooding the station with inert gas. Activation of this fire-control system would also alert the Gas Control Centre and District Headquarters and personnel could immediately be dispatched to the site. The Applicant does not expect a compressor station fire would spread to the surrounding forest or tundra, because a cleared or unforested margin surrounds the station and the various facilities sit on a large gravel pad.

Fires may start on or cross the right-of-way during the operation of the pipeline. The Applicant does not expect that fires will be started by right-of-way maintenance crews because they have fire training, are aware of fire problems, and will be equipped with fire-extinguishing equipment. Fires resulting from pipeline breaks or other failures are not discussed.

Fires Originating Outside the Pipeline System

Fires originating outside the pipeline right-of-way could cross the right-of-way before preventive measures could be taken. While the Applicant expects such fires to pose no immediate danger to the operation of the pipeline, in some areas soil instability could develop and jeopardize the integrity of the pipeline. Soil erosion and, in regions of permafrost, surface subsidence through the degradation of permafrost can follow the destruction by fire of the surface vegetation and the organic layer.

Restoration measures following fires are discussed in Section 13.b.6.3.2. These include insulative covers such as straw (held in place by wire or nylon netting) to prevent or retard permafrost degradation and wire or nylon netting to control wind and water erosion. Permanent repairs would necessitate revegetation procedures similar to those used in the construction phase (Sect. 13.a.6.8).

The Applicant indicates that all fires spotted during the course of line patrol or in re-supply and maintenance flights, will be reported to the relevant government authorities (Sects. 13.b.6.3.1; 14.d.N.2.2.7; 14.d.N.5.3.3). The suppression of fire in the two territories is the legislative responsibility of the Yukon Forestry Service and

the Northwest Lands and Forest Service. The Applicant also indicates (Sect. 13.b.6.3.1) that "If the pipeline's operating conditions permit, personnel and equipment will be immediately dispatched to the site..." and that "Requested manpower and equipment which is not basic to the continuous, safe operation of the pipeline will be made available..."

Concerns

Incidence of Fire

By anticipating no increase in the number of fires during the construction phase (Sect. 14.d.N.7.7.1), the Applicant seems to underestimate the increased risk that arises from the influx of a large labour force. Moreover, although forest and tundra fires are unlikely during winter construction the Applicant has overlooked the possibility of fires smouldering in the organic layer that result from burning the cleared vegetation. Such fires are notorious for persisting undetected under a winter snow cover only to become surface fires some distance from the originating site or at some later time following snow melt. In those areas where timber has been disposed of by burning this danger could be minimized by carrying out a special surveillance in the spring following the clearing.

The level of summer construction activity has not been discussed by the Applicant in the context of fire but has an important bearing on the expected fire incidence. During the first summer, surveying will begin, together with the installation of support facilities. In the second summer, the stockpiling of material will start and in the third summer, the construction of compressor stations (Sect. 13.a.1.1). In addition, the revegetation of slopes will be a summer activity (Sect. 13.a.6.8). The level of activity anticipated can be confirmed by examining the Applicant's projected manpower requirements (Sect. 13.a.5.1, Fig. 1). It has to be remembered that for the less sparsely populated areas of Canada, most forest fires are started by people (Simard, 1973). There seems, therefore, sufficient summer activity to provide ample possible sources for summer fires. Concern over this could be dispelled if it were evident that the Applicant had recognized this danger and had formulated the necessary precautionary plans. For example, during occasions of high fire danger it may be necessary to exclude labour from an area and suspend summer construction activity.

Pipeline Breaks or Failure

The Applicant has not discussed the possibility of fire arising on the right-of-way from a pipeline rupture. Although the statistical probability of this appears very low it cannot be discounted. Fire may follow a rupture (*see* topic "Environmental Safety of Pipeline") and spread to adjacent forest or tundra vegetation (Beak Consultants Ltd., 1974). It does not seem possible to eliminate such hazards altogether, but a recognition of danger and a contingency plan that would permit the speedy transportation of fire-control crews and equipment to the scene, would do much to contain the fire and minimize its damage to the environment.

Fires Affecting Compressor Stations

Concern is felt by the Assessment Group that the dangers associated with fires in or adjacent to compressor and metering stations—and the necessary contingency plans arising from them—have been insufficiently emphasized by the Applicant. In the first place, the delay necessitated by deciding the question of whether or not to alert the relevant government authority after the

Applicant's personnel have visited and inspected the site of a fire, could well make more difficult necessary and effective action by the authority. Secondly, it is not clear why a fire originating in a compressor station could not spread to the surrounding vegetation, for an explosion might well carry burning debris some considerable distance: well over, in fact, the gravel and cleared margin surrounding the station installations. In the same way, it is not impossible for burning debris from a serious forest fire to be carried by air currents right into a station. Both these possibilities do not appear to be considered and the Assessment Group feels that, at the time of an emergency, some improvised control measures might be hastily implemented that could trigger additional environmental damage. The bulldozing of fire guards is an example, which in permafrost areas can initiate serious terrain instability (Heginbottom, 1973; Lotspeich *et al.,* 1970). Recognition of the dangers and a more visible demonstration of contingency plans to meet them would generate more confidence in the proposals.

Restoration and Revegetation Measures Following Fire

Terrain instability might result from a fire in the proximity of the pipeline right-of-way and possibly threaten the integrity of the line. Erosion may be initiated and, in permafrost areas, a variety of instability processes started (Heginbottom, 1973; Zoltai and Tarnocai, 1974). In addition, the quality of waterbodies could be impaired through siltation. As might be expected, such effects will vary among the different terrain types, and are dependent also upon the intensity of the fire, the degree of loss of organic mat and other factors (Crampton, 1973). The Assessment Group does not consider sufficient emphasis has been given to this potential problem and to the way it might manifest itself in different locations.

Concern also arises over the measures proposed to restore terrain stability following fire, both in respect of short-term restoration measures (Sect. 13.b.6.3.2) and long-term (Sect. 13.a.6.8), for in the case of permafrost areas it seems to be implied that successful revegetation is, in itself, all that might be necessary to prevent permafrost degradation. In fact, a more effective insulating layer may be necessary as is discussed elsewhere (*see* topic "Revegetation"). The solution, therefore, seems a greater recognition of the indirect dangers of fire and the development of remedial revegetation and other practices for different terrain types under different environmental conditions.

Highlights

1. Fires may start both within the pipeline system and outside it. In over-all Canadian terms natural fires in the Mackenzie Valley are of only moderate frequency, but they play an important role in determining the composition of the vegetation. This, in turn, can influence terrain stability and wildlife populations.

2. In less sparsely populated areas of Canada most forest fires are started by people, so there is obvious concern that the increased labour force concomitant with pipeline construction does not increase the frequency of fire. During winter construction the main danger arises from vegetation clearing and burning. A smoulder-fire may be started in the organic mat and remain hidden until it suddenly flares and spreads the following spring. The dangers from summer construction activities are much larger, but do not seem to receive sufficient emphasis in the planning of precautionary procedures.

3. The Applicant has recognized the value of collaborating with the Yukon Forestry Service and the Northwest Lands and Forest Service in designing fire-suppression procedures. Concern is felt by the Assessment Group, however, over the Applicant's proposals for bringing information on pipeline-generated fires to the attention of these agencies. It is not clear that the agencies will always be informed early enough to take effective action.

4. The dangers associated with fires in or near compressor and metering stations appear under-estimated with a consequent lack of emphasis or development of fire-control procedures for such occurrences. Hasty and ill-provised procedures, such as bulldozing fire guards, can sometimes be very damaging environmentally, hence recognition of the dangers and plans to meet the dangers are warranted.

5. The Assessment Group considers that the dangers of fire in permafrost areas have not been sufficiently stressed, especially in regard to revegetation measures. Fire can seriously weaken the essential insulating effect of the vegetation and its associated organic mat, with the result that terrain instability results and the integrity of the pipeline is threatened. More than a simple re-seeding of vegetation may be required to restore surface insulation. These dangers would be appreciably lessened by a more visible demonstration of appropriate contingency measures in the Applicant's proposals.

Literature Sources

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Crampton, C.B., 1973. "Studies of Vegetation, Landform and Permafrost in the Mackenzie Valley: Landscape Survey in the Upper and Central Mackenzie Valley", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-8.

Heginbottom, J.A., 1973. "Some Effects of Surface Disturbance on the Permafrost Active Layer at Inuvik, N.W.T.", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-16.

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8.16 PIPE TESTING

Introduction

It is normal to base engineering developments on sound theoretical principles and to check the various parts of such developments by a program of special practical tests before regular operation is commenced. The proposed pipeline is no exception to this approach. In addition to various mill specifications and tests for the pipe itself (Sect. 8.b.6), the welded, assembled and buried steel pipeline system will be pressure tested after installation in the field to ensure that, as far as possible, the pipeline will safely withstand the very high pressures at which the natural gas will be subsequently pumped through the pipe.

As might be expected for an engineering development that has seen thousands of miles of pipeline installed throughout Canada over very many years, well established and mandatory procedures have been developed for pipe testing by the Canadian Standards Association and the National Energy Board (Sect. 13.a.7). Essentially, segments of the pipeline are tested in succession, using a liquid test medium at a high pressure. In non-permafrost areas, the Applicant proposes to use water as the test liquid, and in permafrost areas a so-called "water-freeze depressant solution" that will not freeze when used below 32°F. The currently favoured non-freezing liquid is a water-methanol mixture. The entire testing program, it may be remarked, has to be submitted in detail to the National Energy Board for prior approval.

Environmental concern arises in three main ways. The first stems from the large volumes of water that might be extracted from watercourses of small flow. The second centres on the disposal arrangements for the waste test liquids, be they warm water or the water-methanol mixture. Large volumes of liquids are involved, and the testing process will doubtless contaminate them to some degree with residues cleansed from inside the pipe, which may have a potential for harming water bodies, soil and vegetation. The third concern arises from the possibility of a pipe rupture during actual testing. As before, large volumes of potentially harmful liquids would be released, but in this instance little control over disposal arrangements seems possible. Under some conditions the whole of a test length of pipe might empty itself into a water body.

The Assessment Group considers that the information on certain aspects of pipe testing requires amplification and they have been embodied in "Requests for Supplementary Information" (#40). In the present review the environmental concerns are elaborated and potentially harmful aspects of the proposals pin-pointed. Accidental leakage of test liquids is an inherent risk in pipe testing, but for the more environmentally sensitive sections of the pipeline route, it may be possible to modify the testing procedure to minimize the damage leakage would do.

Applicant's Proposals

The field testing procedures proposed by the Applicant are described in Sections 13.a.7, p.60 and 14.d.N.5.3.2, p.12. The whole of the 1,200 miles of pipeline system installed in Canada north of 60°N. will be tested in lengths of 10 miles or less at a time. Test pressures based on a 1,680-lb/sq in. guage operating pressure will be used for the pipeline system between compressor stations and a 1,690-lb/sq in. guage operating pressure within station facilities.

For non-permafrost areas, water will be the test liquid and, if testing is done in winter, the water will be warmed to 50°F and discharged in the 34-to-38°F range. For permafrost areas, testing will be done in winter using either warm water or a water-methanol mixture. The choice and precise procedure will depend upon geothermal analyses, but it is expected that the water-methanol mixture to be used will not exceed 26 per cent (v/v) in methanol content. This mixture remains liquid down to 0°F.

When water is used as the test liquid, it will be discharged after each test into watercourses or onto ice over watercourses. The water-methanol mixture will be re-used for successive tests, then ultimately disposed of by two possible methods. In the first, the waste is diluted with water so that the methanol content is reduced to one per cent. As far as one can tell (Sect. 13.a.7, p.61) this diluted waste is then discharged into water bodies or onto ice, as above. In the second method, the waste is distilled (separating recovered methanol as the distillate) from an essentially aqueous residue that again contains not more than one per cent of methanol. The recovered methanol will be burnt or used again for secondary purposes, whilst the aqueous residue or so-called "reduced solution" will be sprayed onto land or snow surfaces. In all cases the discharge of mainly aqueous residues will be done in a way to avoid flooding, erosion or siltation.

In a paragraph that may relate to the spillage of water or the water-methanol mixture in the event of a pipe rupture, it is indicated that if water is being used, this will either be allowed to disperse via the natural drainage or, where there is localized flooding, be removed using suction pumps. For a water-methanol spill, this will be allowed to pond, then as much as possible transferred by suction pumps into bladder-type storage tanks for subsequent re-use or disposal by one of the methods described above.

Regardless of whether water or a water-methanol mixture is used for pressure testing, a final drying of the test section of the pipe is carried out using methanol alone. The methanol recovered at the end of these drying runs will be re-used or disposed of as described above for water-methanol mixtures.

Concerns

General

To assist the reader it is necessary to add a few basic statistics to those provided by the Applicant. First, most of the pipeline route north of 60°N. passes through permafrost terrain (*see* topic "Arctic and Conventional Construction Methods"). Therefore, warm water or a water-freeze depressant solution will be the required fluid in most of the 10-mile pipe sections instead of water at ambient temperature. Second, the volume of a 10-mile section of pipe is 3.9 million Imperial (4.7 U.S.) gallons. This is a large volume of water to extract from some northern watercourses during the low-water, winter stage. If a freeze depressant is used, up to 26 per cent (approximately 1 million Imp gallons) of the total volume will be pure methanol. This large volume of a potentially hazardous chemical will require safe storage and careful handling. The water-methanol mixture freezes at 0°F. Storage of the 3.9 million gallons of this mixture between testing periods may also present problems. Finally, if the 3.9 million gallons of fluid contained in a 10-mile pipe section were to spill after a pipe rupture, it could theoretically form a lake a foot deep covering 14 acres.

Statistics associated with the disposal of the

test liquid are similarly helpful. Where water is used for testing, the same large volumes as indicated above will be discharged for each 10-mile pipe section. For the repeatedly used water-methanol mixture, in order to reduce the methanol from 26 to one per cent by dilution with additional water, nearly 100 million gallons of water will be required, and then, over 100 million gallons of one-per-cent methanol solution will have to be disposed of. The alternative treatment—distillation—also suggests shortcomings. First, a large volume has to be distilled. Secondly, a sharp separation of the two component liquids may not occur unless a very special fractionation procedure is designed. Some water may be carried over with the methanol but probably not enough to inhibit its subsequent combustion. More importantly, it may be difficult to lower the methanol content of the aqueous residue to one per cent, and even this concentration may constitute a biological hazard when discharged into watercourses. Finally, the repeated use of the water-methanol mixture on successive 10-mile pipe sections, and its at least partial separation by distillation, will serve to concentrate in the aqueous residue any substances cleansed from the pipe. These may not be harmless when released on certain environmental components.

Water Requirements

For the permafrost areas far more water will be required if fresh lots of 3.9 million gallons are used for successive 10-mile pipe sections than if one water-freeze depressant mixture is used over and over again. Water will be extracted from rivers, streams or lakes. For much of the pipeline route, large rivers are nearby and no environmental problem is seen, provided the detailed plans are available for study by the appropriate regulatory authority before the final design stage. A special problem is seen on the Yukon North Slope, however, for none of the streams near the pipeline has a significant winter flow, and water would have to be drawn from small lakes, although these are rare west of the Firth River. Other aspects apart, therefore, the repeatedly used water-methanol mixture appears a less potentially damaging possibility provided the approximately 3 million gallons of water for the mixture could be tapped from a large water body in a way acceptable to the regulatory authority. For the non-permafrost areas, where repeated volumes of 3.9 million gallons of water are required, river sources with appreciable flows are nearby and no special problems are seen.

Normal Disposal Arrangements

For non-permafrost areas the disposal of 3.9 million gallons of waste water, at 34 to 38°F or at the ambient temperature, into watercourses or onto frozen watercourses should not pose a threat of thermal pollution, provided the river-water flow is large compared with the waste contributed. Concern would arise, however, if this were not so, for aquatic organisms could be adversely affected. The release of water in winter may change ice characteristics and the time of spring break-up, affecting in turn the pattern of fish migration. Similarly, the release of waste water into open channel areas may adversely affect overwintering fish or incubating fish eggs in the river gravel (*see* topic "Waste and Toxic Materials"). Particular concern arises from the substances or materials that may be cleansed from the pipe by the test water, for such compounds could seriously impair water quality and aquatic habitat. Presumably, information on such compounds will be submitted by the Applicant, so that when the regulatory authorities consider how the disposal arrangements might fulfill the requirements of the relevant Acts (e.g. Arctic Waters Pollution Prevention Act, Northern Inland Waters Act, Fisheries

Act, Canada Water Act, Canada Shipping Act, and Territorial Lands Act), the Regulations (e.g. Territorial Land Use Regulations for Yukon and Northwest Territories), and the Territorial Ordinances (Yukon and Northwest Territories), all pertinent information is available. At present, this information is not documented, so that an unknown danger presents itself.

For permafrost areas, the disposal of waste water raises the same concerns as expressed above. When the water-methanol mixture is used the concerns seem even more serious. The Assessment Group does not favour disposal of the diluted (i.e. to one per cent methanol) mixture into watercourses because, as is explained elsewhere (*see* topic "Waste and Toxic Materials"), there is considerable doubt as to the harmlessness to aquatic organisms of even these very diluted methanol solutions, quite aside from the unknown contents of compounds cleansed from the pipe such water-methanol residues may contain. Moreover, as the water-methanol mixture is used for successive 10-mile pipe sections it may be expected to contain more extracted compounds than the once-used equivalent volumes of warm water, quite aside from any greater contents arising from its better solvent powers compared with water. If the distillation treatment were used no concerns would arise from a careful burning of an essentially methanol distillate. The disposal of the aqueous residue containing cleansed compounds from the pipe and possibly some undistilled methanol, however, does cause concern. Regulatory agencies would undoubtedly require information about the composition of the aqueous residue and its potential impacts on the environment before approving a method of disposal. The alternative suggestion—spraying onto land and snow surfaces—is possibly environmentally acceptable, provided much more information is furnished by the Applicant than is currently available. In this alternative, an area of some 100 to 150 acres could be selected where the 3 million gallons of waste liquid (equivalent to one inch or so of water) would be spread and would only find its way into the drainage system after its potentially harmful ingredients had been filtered off, absorbed and neutralized by the soil. It would be important that the addition of such a volume of waste water does not kill the vegetation or cause terrain instability by promoting the thawing of the permafrost.

Pipe Rupture Leakages

Considerable disquiet is felt by the Assessment Group with regard to the leakages of warm water or a water-methanol mixture that would result from pipe ruptures during testing. In the first place, no estimate has been provided by the Applicant on the number of such ruptures expected per 10-mile pipe section, so that the fundamental scale of the concern is undefined. Secondly, it is not explained how quickly a rupture could be temporarily plugged. Which is more likely, for example, that almost the entire 3.9 million gallons of test liquid will escape from the rupture or that crews will be at the ready to prevent more than a fraction escaping? In the absence of any evidence suggesting otherwise, it has to be assumed that under some circumstances the entire 3.9 million gallons of warm water or water-methanol mixture could escape at any point along the pipeline right-of-way regardless of terrain type. Clearly, on or near watercourses, a variety of environmental catastrophes could occur. These include localized thermal pollution and ruination of aquatic habitat for a year or more. This would lead to death of fish and muskrat, and the impairment of water quality. On land, vegetation could be killed and the thawing of permafrost initiated. Erosion and siltation could arise directly. Serious effects could occur as a water-methanol mixture diffused through the voids in the backfill

of the pipe trench, changing the thermal regime, melting the permafrost, and leading to the progressive development of terrain instability. Unfortunately, it is difficult to judge the efficacy of the proposed remedial actions—ponding, suction pumps, and bladder storage-tanks—because nothing is said as to how quickly such equipment could be transported to a pipe rupture and put into action. In the absence of such information, therefore, and on general principles, there seems an advantage in reducing the length of pipe section tested in the more sensitive terrain types and in using water alone rather than the water-methanol mixture. Leakages could thereby be reduced and the liquid released made less damaging. If by the final design stage a water-freeze depressant other than methanol is proposed, the environmental implications of the new material would warrant scrutiny.

Highlights

1. Before regular use, the assembled and buried pipeline is tested to ensure it will withstand the high pressures at which the natural gas is pumped through the system. Up to 10-mile-long sections are tested at a time at high pressures, using either warm water or a water-freeze depressant solution comprising water and methanol in the volumetric proportion 74:26.

2. Large volumes of test liquids are involved because a 10-mile section holds 3.9 million Imperial gallons. For the more northern permafrost areas the same lot of water-methanol mixture is used for successive 10-mile pipe sections, but for the non-permafrost areas—and for some of the permafrost ones—water alone is used, a new lot being used each time.

3. No physical difficulty is seen in withdrawing the required volumes of water from water bodies adjacent to the pipeline along the Mackenzie Valley. However, on the Yukon North Slope rivers in winter carry little or no water, and the required volumes will have to be hauled from small lakes. In all instances the water needs and proposals would have to accord with the requirements of the various authorities regulating water use.

4. The disposal of the 3.9 million Imperial gallons of waste water into watercourses after each test could impair aquatic habitat and organisms if the river flow were small compared with the waste added. Specific disposal plans would have to meet the requirements of the relevant Acts, Regulations and Ordinances relating to water.

5. The proposal to dilute the water-methanol mixture with additional water until it contains only one per cent methanol, and then to discharge it into water bodies has disadvantages. The volume of waste liquid to be disposed of rises from 3.9 million to more than 100 million gallons, and it may still be harmful by reason of the methanol and waste substances it contains. The distillation proposal seems more attractive because the methanol distillate could be burnt without environmental damage or re-used. However, the aqueous residue would still present a problem for disposal, but it might be possible to find a 100- to 150-acre area with particular properties where this residue might be discarded without environmental harm.

6. Considerable disquiet is felt by the Assessment Group with regard to the leakages of water or water-methanol that would follow a pipe rupture during testing, for these could occur at any point along the right-of-way. No information is provided on the frequency of such ruptures or of the quantities of test liquid likely to be released. The problem is seen to be inherent in testing and not altogether avoidable. The

likelihood of environmental damage might be lessened, however, if in particularly sensitive sections of pipeline, shorter lengths were tested at a time and water, rather than the water-methanol mixture, were used.

Literature Sources

"Gas Transmission and Distribution Piping System", CSA Standard Z184-1973, Cdn. Standards Assoc., Rexdale, Ont.

"National Energy Board Act and Gas Pipeline Regulations", 1974. Available from Information Canada, Ottawa.

8.17 CONTINGENCIES AND MONITORING

A number of environmental concerns are involved in those aspects of pipeline development that pertain to monitoring and to the handling of contingencies during both the construction and operation phases of the project, as highlighted in "Expanded Guidelines for Northern Pipelines". The "Requests for Supplementary Information" seek information from the Applicant regarding several aspects of these subjects, including off-road vehicular traffic required for contingency repairs, scheduling and environmental consequences of delays, spillage of toxic materials, contingency plans—river crossings, and monitoring.

The "Requests for Supplementary Information" #22 state, "Major pipeline repairs, especially replacement of a failed portion of the line could necessitate off-road movement of heavy equipment (Section 13.b.6.1.3, p.28) and could possibly involve serious damage to vegetation and terrain. Some intervals of terrain might not be negotiable by surface vehicles regardless of degree of damage. Movements of equipment and vehicles on the ground or by air might be restricted at certain seasons because of sensitivity of bird, mammal, or fish populations" and ask the Applicant for specific information which could assist in assessment of the magnitude of potential adverse impacts. Further comment in this regard is delayed pending review of the Applicant's response.

On the same basis, further comment has been delayed regarding monitoring. Particular concern in the "Requests" has been directed to performance monitoring or surveillance aimed at detection of early signs of potential threats to the pipeline system and to the environment. Contingency plans and procedures are discussed in various other topics of this report.

8.18 PIPELINE INACTIVATION OR ABANDONMENT

Introduction

Technological developments may pose little threat to the environment when operating, but the same may not always hold when they end their useful life. Disintegrating industrial facilities and ruined landscapes are two of the more visible eyesores that often live on for years, quite aside from less obvious deeper-seated changes to land stemming from harmful emission or other artificial processes. Is there any possibility that the pipeline development will be similarly viewed? In other words, regardless of how acceptable the pipeline might appear environmentally when it is operating, does the evidence provided suggest it can be made to operate without, at the same time, building up insoluble or intractable problems for that distant future date when it becomes inactive or unused?

For a pipeline in the southern regions of Canada, no particular environmental problems would be expected to result from inactivation or abandonment. The pipeline itself would be sealed off from all connecting facilities, purged of natural gas, and filled with an inert gas to eliminate the possibility of fire or explosion. Locally, some special dismantling would be necessary if the buried pipeline constituted an impediment to construction and, of course, monitoring would be required to detect any rusting that could lead to pipe disintegration and soil collapse. In the northern permafrost regions the situation is different. The technology selected now to secure the operation of the Canadian Arctic Gas pipeline may have a great bearing on the options possible when the line becomes inactive. The explanation is not simple and arises in the following way. In order not to melt the permafrost through which the pipeline passes and thereby cause a variety of engineering and environmental problems, the Applicant proposes to chill the natural gas to well below the freezing point of water. When the pipeline is operated under these conditions natural permafrost is preserved, but where it passes through unfrozen ground in areas of discontinuous permafrost, artificial "permafrost" may form around the pipe through the long-continued passage of the chilled gas. In this process, ice lenses may also form where the soil's physical characteristics are suitable, so that, in effect, bodies of artificial but sensitive ice-rich permafrost are built up. Upon inactivation or abandonment of the pipeline, applied chilling ceases and sooner or later the artificial permafrost reverts to its unfrozen state. Where the applied chilling produced ice lenses, effects similar to the degradation of sensitive permafrost can be expected, with all their implications for environmental and engineering concerns.

The Assessment Group considers these implications can be realistically assessed only if detailed geothermal and other data are available at the outset on the effects of chilling and its cessation upon representative terrain types. Such information might permit a modification of the proposed chilling regime and the avoidance of the development of a terrain condition that is stable only so long as it is artificially maintained, a situation from which there is no easy escape when it is desired to inactivate the line. Information relevant to this important aspect has already been included in "Requests for Supplementary Information" (#56). In the following sections, the implications of inactivation or abandonment are explored in greater detail.

Applicant's Proposals

The Applicant proposes to transmit the natural gas at temperatures ranging from 0^{o} to $15^{o}F$ from

the Alaska-Yukon border and from Richards Island southward to almost the Alberta border at 60°N. The natural gas leaves a compressor and chilling station at 15°F and, except for stations M-16 to M-19, arrives at the next station at a temperature somewhere between 10° and 0°F (*see* topic "Chilled Pipeline Rationale"). Throughout the chilled portion of the line, but particularly in the discontinuous permafrost zone which stretches from Little Chicago southward to south of 60°N., the pipeline will encounter unfrozen intervals whose total length is estimated to be 150 to 250 miles.

The Applicant anticipates that the pipeline will be operated for many decades, perhaps six, and has said that when abandonment becomes an issue at this future date there are a variety of alternatives. One presented visualizes the pipe being left in place, it being further suggested that a succession of vegetative growth will occur over the right-of-way, with even the already minor visual evidence of the pipeline eventually disappearing. It is said "...the line would be in stable surrounding soil and would remain 'frozen in' in (the) permafrost soil" (Sect. 14.d.N.6.5). For the pipeline itself, the other alternatives are not described.

Concerns

The main concern is the possibility of deleterious environmental effects when artificial permafrost, produced by the long-sustained operation of a chilled pipeline, reverts to its unfrozen state following inactivation or abandonment. From the studies so far conducted and presented by the Applicant (Sect. 8.b.1.3.7, Fig. 11) it has been computed that a frozen soil zone or frost bulb as much as 25 to 30 feet across can be generated after a very few years when a buried pipeline is chilled down to only 25°F. There are good reasons for supposing, therefore, that the dangers of artificially induced permafrost are not being exaggerated when it is remembered that the actual chilling temperatures are going to be in the 0° to 15°F range. However, it must be acknowledged that these are the results of a computation and that their extrapolation to the terrain and other conditions that characterize the length of the actual pipeline has not yet been undertaken. No prediction has apparently been made as to where artificial permafrost will be built up and how big or significant it will be. To do these things requires: first, the completion of the Applicant's current research on the problems of frost-bulb formation and frost heave; secondly, refinement of the Applicant's terrain analysis to permit the delineation of those terrain categories traversed by the route where sensitive artificial permafrost is likely to develop.

If the above research shows the concern to be appreciable for particular parts of the route, then either the lengths of pipeline chilled and the chilling temperatures may need to be modified or, alternatively, an above-ground mode of pipeline construction—with all its distinct environmental and other implications—will need a separate investigation and assessment.

The second concern centres on the Applicant's assumption that in the areas of natural permafrost the pipeline would remain "frozen in". Although this may be true for the operation of a chilled line, the same may not be valid for all natural permafrost areas traversed when chilling ceases. The latter situation would arise where the surface vegetation and organic mat were essential for the maintenance of the natural permafrost and where, on the disturbance of these protective layers, the protection against thawing depended not so much on the newly established vegetation as on the artificial chilling. When chilling ceased, therefore, the artificially maintained permafrost would

melt and terrain instability, with other environmental consequences, could ensue under appropriate conditions. Although revegetation procedures are to be implemented by the Applicant (Sect. 13.a. 6.8), it is explained elsewhere in this Assessment Report (*see* topic "Revegetation") that the natural re-establishment of a surface organic mat after the loss of the original mat can be very slow and take longer than the anticipated working life of the pipe. Not only does this underline the importance of retaining the actual protective organic mat over the pipeline right-of-way, but it again indicates the need to have a full geothermal analysis and other data for the right-of-way to know the relative strengths of the different forces that control the stability of the frozen soil. As before, such knowledge is only a first step that puts dimensions on the environmental concern. The next step, to avoid an insoluble problem several decades in the future, might be to modify the chilling regime or consider an above-ground mode of construction for certain lengths of the pipeline.

The third concern centres on an inactivation or abandonment procedure that involves digging up and salvaging the pipe. Although this is not specifically proposed as an alternative by the Applicant, it is not an unknown and unfeasible possibility. It would clearly involve numerous operations similar to those proposed for pipeline development and which pose threats to the environment unless special precautions are taken. For a salvaging operation, therefore, suitable precautions would be necessary, and they would have to be tailored to meet the local sensitivities of terrain and biota.

Highlights

1. Although concerns centred on the inactivation or abandonment of a gas pipeline that is expected to operate for several decades may seem highly premature, certain proposals of the Applicant or alternatives relating to abandonment warrant examination now, for changes to basic plans and operating procedures may be suggested that will avoid future problems.

2. The Applicant suggests the pipe could be left in place. The environmental concern associated with this proposal stems from the fact that the stability of the pipeline and its adjacent terrain may have come to depend on the long-continued operation of the chilling regime. When it ceases, therefore, both natural and artificially-induced permafrost may thaw, leading to a variety of serious terrain problems, such as slope instability, differential settlement and erosion.

3. An alternative possibility is to remove the pipe from the ground at the end of its active life. This removal of the pipe could lead to the same thawing of natural and artificial permafrost mentioned above and also would involve operation of heavy equipment and its aftermath that would raise environmental concerns similar to those associated with pipe installation.

4. It is obviously undesirable to create a problem for the future that may have no easy solution. At the present time, however, measures ensuring the avoidance of the problem are not well known. The nature and extent of permafrost degradation and environmental disturbance that would follow abandonment of the chilled line remain to be fully investigated and described, as do the various factors controlling the extent of the problem and the procedures that might be implemented to lessen it.

5. Research in the above areas could provide an informed review of abandonment problems before final decisions are made regarding pipe installation. Information would be provided on frost-bulb formation and frost-heave around a chilled pipe, the results of monitoring and experimentation at test

facilities and sections of the pipeline right-of-way where, on a mile-by-mile basis, terrain instability on abandonment could be expected, and where from the outset special mitigating measures should be designed and implemented.

CHAPTER 9

ENVIRONMENTAL QUALITY *

9.1 PORCUPINE CARIBOU HERD

Introduction

The Porcupine caribou herd is one of our outstanding natural heritages. It has flourished until now because of the isolated and undeveloped state of its habitat, but is vulnerable to changes that may accompany industrial development and increased contact with people. Its continuing viability is of concern to Canada, to the United States, and to the native and other people now living in the region.

The herd, named after the Porcupine River and numbering some 110,000 to 140,000 barren-ground caribou (*Rangifer tarandus*), is the largest group of animals along the proposed pipeline route. Feeding on lichens and grasses, the herd migrates through central and northern Yukon and adjacent parts of the Northwest Territories and Alaska, thereby constituting a joint Canadian and United States' responsibility.

The broad migration pattern in relation to the pipeline route, physiography and settlements is shown in the Figure. Summer is spent in the northern Yukon and adjacent Alaska, and in fall the animals move south to the Peel River drainage basin where they overwinter. In spring, they move northwards to the Arctic coast, and calves are born from late May to mid-June as the herd swings westwards along the North Slope of the Yukon into northeast Alaska. Although caribou are no longer an absolutely essential source of food to the people of the region, they are still a very important one, particularly in Fort McPherson, Aklavik, Old Crow and in several Alaskan villages.

As might be expected, migrating caribou are easily disturbed and the unfamiliar activities of pipeline development, such as low-flying aircraft, equipment noise, blasting and compressor motors, could all interfere with their usual migration patterns with a consequent change in range use and possible increase in mortality. This danger has been recognized by the Applicant in respect of the coastal Yukon route and he has supposed that winter construction will avoid contact with the caribou, except for an area between the Yukon-Northwest Territories border and the Mackenzie Delta (Sect. 14.d.N.7.9.1)

Although the Assessment Group acknowledges this supposition to be mainly true, it also considers—as is developed in detail below—that it is unwarranted and unsafe to over-generalize on the caribou's annual migration pattern. In fact, considerable year-to-year variability in migration

* Additional material relating to wildlife may be made available subsequent to this report.

seems the rule, with the resulting necessity of devising a contingency plan for pipeline-caribou conflicts capable of taking this into account. Aspects of this have already been the subject of "Requests for Supplementary Information" (#46). The important impact of parallel developments in the North, such as the Dempster Highway, must also be placed in context.

Applicant's and Other Data

Surveys made during 1971 and 1972 showed that in these years most of the Porcupine caribou herd wintered in the central Yukon utilizing the entire Porcupine Plateau. During 1972-73, however, the winter distribution differed. The herd moved more to the west into Alaska in the area around Arctic Village. No data were provided by the Applicant for the later part of the 1972-73 winter or subsequent to this.

Other observations made by DeBock and Surrendi (1974) in 1973 and 1974 also showed appreciable variation in winter distribution and in spring movements, suggesting a general picture of marked year-to-year variability, hence unpredictability, in migration pattern. Therefore, although pipeline development will avoid the more frequently used areas of winter habitat, there is no guarantee that in particular years conflicts will not occur. In addition, it must be noted that a small but important part of the herd—normally numbering about 5,000 animals but increasing to 20,000 in 1972—overwinters on the eastern slopes of the Richardson Mountains in the Northwest Territories; the herd is an important food source for the native people of Fort McPherson and Aklavik.

Concerns

General

The most important concern is that the proposed Prime Route crosses the critically important calving area in the northernmost part of the Yukon (*see* Figure). Conflict will also arise if construction takes place during winters—such as 1973-74—when animals overwinter on the North Slope. The proposed Prime Route circumvents the major spring and fall migration paths.

Habitat Changes

Loss of habitat will occur on the right-of-way itself and on the sites of associated facilities, such as compressor stations and roads, but these losses are relatively insignificant. However, certain topographic features within a landscape, such as river crossings or passes, are considered to be important and the loss of such features, especially within calving areas, could trigger unexpected behavioural responses. Fires are neither numerous nor extensive in northernmost Yukon (Barney and Comiskey, 1973), but any increase over their natural frequency caused by pipeline activities is undesirable, for caribou avoid burned areas.

Disturbance

Both the construction and operation phases of pipeline development involve actions potentially disturbing to caribou. The former includes increased human activity, the operation of heavy construction equipment, blasting and aircraft.

The latter includes compressor stations and aircraft surveillance flights. There is also the very dangerous situation arising from pipeline breaks, when a variety of actions might be necessary at a particularly vulnerable time in a particularly sensitive area.

The effects of disturbance on caribou are not well documented. Both Geist (1971) and Skoog (1968) have shown the damage caused by aircraft harassment, the caribou's winter energy expenditures being raised with a consequent decrease in the survival rate of the newly born young. The same has been demonstrated by Zhigunov (1968) for the closely similar reindeer in Russia. Disturbance is also damaging in summer, especially in the midsummer post-calving season, when the animals' condition is depressed through nursing demands and the adverse combination of biting insects and summer heat. In effect, therefore, the winter to late summer period (December 1 to July 31) is a particularly sensitive one.

Disturbance by Aircraft

The use of both large and small aircarft, especially helicopters, is proposed by the Applicant for both construction and operation phases to transport men and materials along the route. The reaction of caribou to aircraft is not straightforward and depends, among other factors, upon the altitude and type of aircraft on the one hand, and the herd size and time of year on the other. From his studies the Applicant has concluded that a minimum altitude of 1,000 feet above ground-level should apply at all times of the year (Sect. 14.d.N.7.9.1), although he recognized that "Reactions to aircraft at altitudes greater than 1,000 feet are unpredictable but, as a rule, infrequent". (Biol. Rept. Ser. Vol. 5, p.201). Observations made by the Canadian Wildlife Service (DeBock and Surrendi, 1974) agree with this and both authorities say that an adequately enforced control of aircraft would reduce the more serious effects of this hazard.

Winter Construction Disturbance

The Applicant has stated that winter construction (November to April) "...will avoid interaction with caribou in all winter habitats" (Sect. 14.d.N.7.9.1) and "...will virtually eliminate interaction with caribou (Porcupine herd) during all phases of the animal's life cycle." (Sect. 14.d.N.6.3.7). In the event that this proves to be not entirely the case, the following precaution is indicated, "...herds will be kept under surveillance during this period to warn of any unexpected occurrence that would require contingency measures." (Sect. 14.d.N.6.3.7). Contingency measures that are considered to be satisfactory by the Assessment Group are described in Vol. 5 of the Biological Report Series, pp 174-175 (McCourt, *et al.*, 1974), but the Group is concerned that although these measures are not mentioned by the Applicant in his formal proposals, the unpredictability of the caribou's movement pattern could well necessitate recourse to their use.

Summer Construction Disturbance

For the critical calving and post-calving periods, when large aggregations of caribou are moving, the Applicant plans to curtail vehicular traffic. Disturbance could come from other summer construction activities, such as borrow-pit blasting and aircraft. Although the Applicant's proposals in respect of surveillance will permit awareness of possible interactions and the implementation of appropriate contingency measures, the importance of avoiding the disturbance of caribou during calving cannot be over-emphasized.

Compressor-Station Disturbance

Longer term disturbance may be caused by permanent structures such as airstrips, access roads, equipment stockpiles, and communication towers, but compressor stations are expected to be more serious by reason of the continuous loud noise they emit. Studies conducted by the Applicant testing the effect of simulated compressor-station noise have shown that caribou more than 220 yards from the source of noise are unlikely to be displaced. These results, however, relate to short-term trials and the effects of long-continued noise emission could induce more fundamental adverse effects upon the animals' behaviour.

Improved Public Access

At present, access and hunting pressures constitute no threat to the herd (DeBock and Surrendi, 1974). As this situation could change as a result of improved access and increased travel, the pressures on the herd, and their effects, should be kept under surveillance.

Dempster Highway

The Dempster highway will cross the Porcupine caribou herd's winter range north of the Peel River and its spring migration route through the Richardson Mountains. When the highway is completed, both the traffic on it and hunting from it could have a profound effect on the herd. The size of the herd could be reduced and the time and path of migration could be altered. The impacts of the pipeline on the herd discussed above must, therefore, be viewed—and reviewed—in the context of these future changes. Of course, to the extent that the pipeline development uses the Dempster Highway, either directly in moving supplies or indirectly in generating incidental traffic, it will contribute to the interaction between caribou and potentially damaging forces.

Highlights

1. The Porcupine caribou herd is one of Canada's outstanding natural heritages and its continuing viability is of both general and local importance.

2. Although the proposed pipeline route avoids the major spring and fall migration routes of the herd, there appears to be so much year-to-year variation in particular migration paths that there is no assurance that conflicts between migrating caribou and pipeline-construction activities will not occur. The chances of such conflicts could be substantially reduced if contingency measures similar to those detailed on pages 174-175 of Vol. 5 of the Biological Report Series sponsored by the Applicant could be immediately and effectively implemented.

3. The proposed Prime pipeline route crosses the critically important summer migration and calving grounds in northernmost Yukon (Figure). Winter construction will ensure less disturbance to caribou during the sensitive summer period, but damage can still arise from several summertime activities. Such damage could be minimized by ceasing to operate noisy equipment, aircraft and blasting when surveillance indicates nearby concentrations of caribou.

4. Loss of habitat on the pipeline route itself or on the sites of facilities presents no significant threat but changes to familiar topographic features or an increased incidence of fires could be very disturbing. Successful revegetation techniques, no undue disturbance of natural landscape features and efficient fire-precaution practices would obviate this danger.

5. During both the construction and operation phases of pipeline development harm to caribou

could arise from noise, whether generated by aircraft, equipment, vehicular traffic, blasting or compressor stations.

6. The relevant length of pipeline route stretches from Mile 195 at the Alaska-Yukon frontier to Mile 430, somewhat north of Fort McPherson. For aircraft, problems would be avoided if aircraft were obligated to fly at altitudes exceeding 1,000 feet (above ground-level) when caribou are in the vicinity. A supervising biologist could instruct on the latter and on the suitability of particular flight corridors when large aggregations of caribou are in the area of concern.

7. Compressor-station noise at stations CA05, · CA06, CA07 and CA09 is considered potentially disturbing but suppression measures should alleviate much of this hazard.

8. Importance of the effect of the pipeline on the carbou herd cannot be evaluated in isolation; rather it must be viewed in the context of possible changes in herd size and migration pattern that may follow opening of the Dempster Highway.

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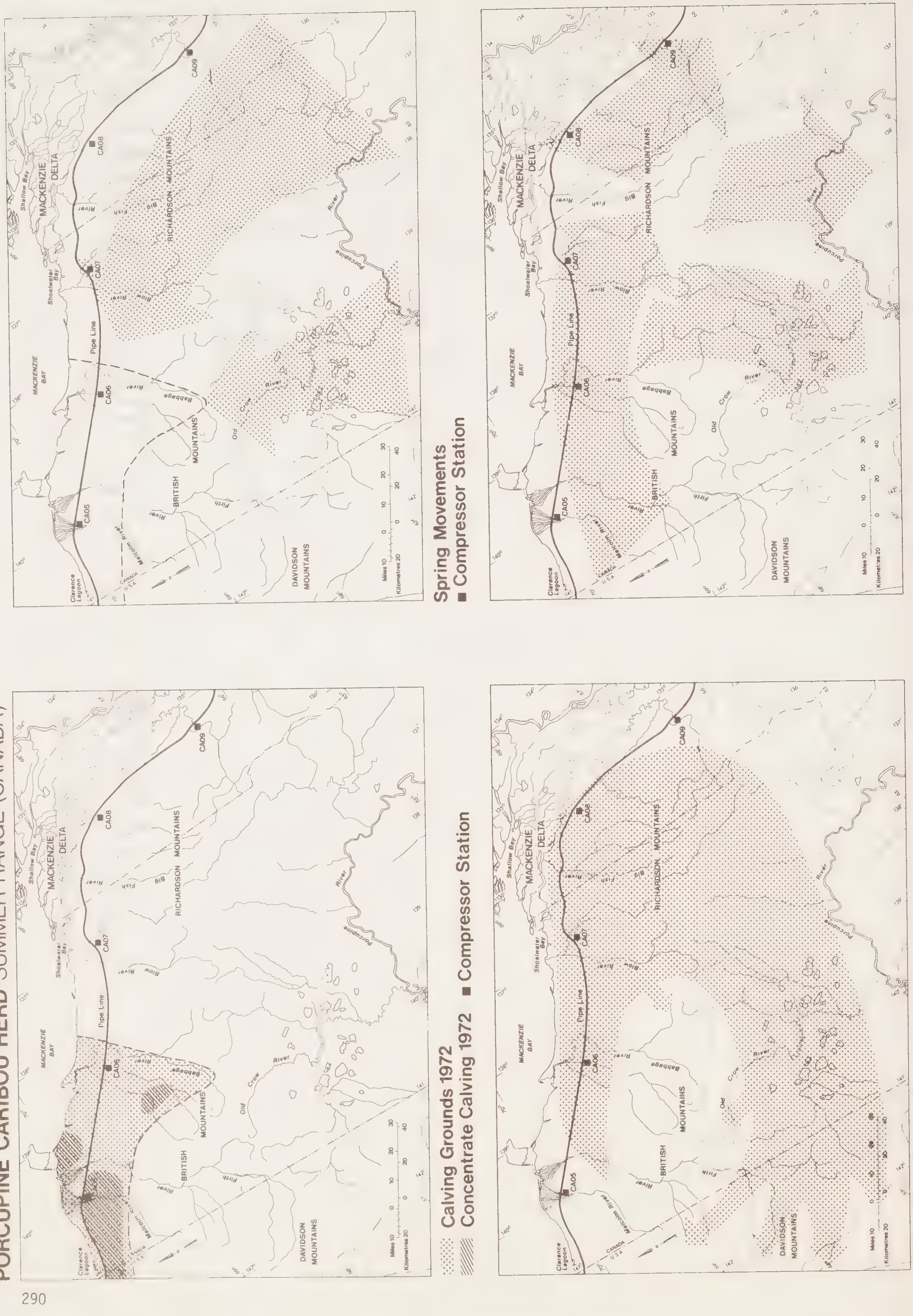
PORCUPINE CARIBOU HERD SUMMER RANGE (CANADA)



Calving Grounds 1972
Concentrate Calving 1972 ■ Compressor Station

Spring Movements
■ Compressor Station

Post-Calving and Mid-Summer Movements
■ Compressor Station

Fall Movements
■ Compressor Station

9.2 DALL'S SHEEP

Introduction

In remote wilderness areas rare or unique wildlife species may not be able to withstand disturbance from modern technological development. Their existence is precarious at best and they may be driven from their normal habitat to the point of extinction. Dall's sheep (*Ovis dalli*) are such a species. Unique to northwest America, they are primarily a pure white species of thinhorn mountain sheep whose range extends from northern British Columbia into the Yukon Territory and Alaska, overlapping into the Northwest Territories in the Mackenzie and Richardson Mountains. Throughout this range they occur as discrete populations, preferring open mountain sides and tops where they exploit the sparse alpine vegetation and find safety from predators on nearby precipitous slopes and cliffs. Like other mountain sheep, the populations have established movement patterns, ranging widely in summer, but returning in winter and at lambing time to especially favourable areas. These wintering and lambing areas are limited in extent and availability and thus govern the size of the sheep population and are a critical factor in the survival of the species.

In the vicinity of the pipeline route there are two known Dall's sheep populations. One is in the northern Richardson Mountains on the Yukon-Northwest Territories border and the other is along the Firth River (Yukon). The major environmental concern centres on the first population because the proposed pipeline route lies in such close proximity to the Richardson Mountains habitat. The route adjoins the sheep's sensitive winter and lambing area and pipeline construction and operation could have considerable impact on the population unless precautions are taken such as those identified in subsequent paragraphs.

In the Firth River area the threat arises only indirectly through the possibility of easier public access to the sheep range.

Applicant's and Other Data

A study of Dall's sheep along the proposed pipeline route was undertaken for the Applicant in 1971 (Biol. Rept. Ser. Vol. 4). Ten distinct populations were located but only one was close enough to the route to be exposed to possible direct effect. The Mount Goodenough population in the northern Richardsons was estimated at about 450 sheep, many of which winter on the eastern slopes of Mount Goodenough. The Firth River population, the next closest, is smaller. As it is more than 15 miles from the Yukon coastal route no direct effect is expected.

The winter range of the Mount Goodenough sheep in 1971 was reported to have included the spruce forests that form a narrow fringe around the eastern base of Mount Goodenough (Biol. Rept. Ser. Vol. 4). However, a study referred to as having taken place in February, 1973 (Sect. 14.d.N.7.9.3), but not documented, showed that these lower forested areas were not used during that winter.

Studies on sheep behaviour conducted during 1972 for the Applicant were limited to one investigation, when a compressor-station noise simulator was used (Biol. Rept. Ser. Vol. 5). This showed that within one mile of the simulator, most of the sheep were displaced. Helicopter activity produced an even greater adverse reaction, and the report suggested further that a generally similar reaction might result from noise of construction equipment. The irregularity of blasting and its associated earth tremors are considered to disturb sheep even more.

Surveys were undertaken on the Mount Goodenough population in 1971-72, 1972-73 and 1973-74 by the Canadian Wildlife Service (Simmons, 1973; Watson *et al.*, 1973; and Nolan, 1974). The three winter ranges outlined by the surveys are shown on the accompanying Figure in relation to physiographic features, the proposed pipeline route with its associated facilities, and the mileages. As can be seen, the pipeline route skirts the eastern slopes of the mountain from Mile 371 to 406, just below the sensitive range of the sheep, and passes particularly close to the critical lambing area. No formal disturbance studies of these areas have been made, but numerous observations have been recorded on the adverse reactions of sheep to aircraft, noise, and nearby human presence.

Concerns

General

Although the Figure makes it clear the proposed route does not cross Dall's sheep range, it will pass "within one mile" (Sect. 14.d.N.7.9.3, p.51) of the very important wintering and lambing concentration area described above. Here, as many as 150 to 180 sheep winter from approximately October 15 to May 1 (Nolan, 1974). Lambing then begins in early May, peaks in the latter part of May and continues to mid-June. If construction proceeds after mid-June these sensitive periods can be avoided, but as all construction is scheduled for winter (December to April) it is expected the combined activity of human presence, lights, construction noise and aircraft will cause some displacement of sheep during the period this activity is to take place (Sect. 14.d.N.7.9.3).

The degree of such displacement and its significance are difficult to forecast. On the one hand, it may prove only temporary, for other sheep species have been known to adapt to human presence and to noise. At the other extreme, it may prove disastrous. A mass exodus from these traditional wintering and lambing areas could occur, and the sheep's normal pattern of winter return could be permanently disrupted. As suitable habitat in the Richardsons is already limited, a high mortality could result from starvation and increased predation.

Aircraft

The results of one study on the effects of aircraft demonstrated an extremely adverse reaction, especially to helicopters; observations by other researchers support this. Although "aircraft control" is advocated by the Applicant, he does not indicate the degree or type of control necessary to eliminate harmful disturbance.

As sheep may be displaced by helicopters at distances greater than one mile (Biol. Rept. Ser. Vol. 5), and the route along the Richardsons between Miles 390 and 395 lies within one mile of sheep range, the concentrated use of helicopters during construction along this stretch is likely to cause displacement.

Aircraft seem to cause more disturbance to sheep than they do to caribou, moose or grizzly bear (Simmons and Nolan, pers. comm.), hence the recommended altitude for flights over the latter—1,000 feet (Biol. Rept. Ser. Vol. 5, p.182)—may not be sufficient to avoid harmful effects to sheep. In view of the fact that the winter and critical lambing ranges are quite well known, it would be best to restrict overflights of this area to a minimum and to an arbitrary height of 2,000 feet above ground until further studies establish safe height limits. Furthermore, as the stretch of the pipeline between Mile 371 and 406 is also one in which aircraft could cause disturbance to sheep, flights here would best be kept

to a minimum.

The effects of the continued use of aircraft for surveillance and maintenance have not been investigated, but in such cases there is a greater possibility of acclimatization of sheep to the less frequent and more regular flights involved. In contrast, aircraft used during major repairs would have effects similar to those resulting from construction activities.

Compressor Stations

Studies have shown that unmuffled compressor-station noise displaces sheep within one mile, but the Applicant does not locate any compressor station within this distance of sheep range.

Construction Noise

If McCourt's suggestion (Biol. Rept. Ser. Vol. 5, p.134) proves valid, viz. that noise disturbance of construction equipment may resemble that of helicopters and sound simulators, then displacement of animals during winter construction is inevitable. The Applicant has acknowledged that short-term displacement may occur, but suggests no protective measures, except aircraft control, that would alleviate this situation. The Environment Protection Board (1973) has stated that "...noisy machinery, roadways, airstrips and similar developments should not be located within five miles of known Dall sheep ranges..." but no data are presented to support this recommendation.

From the meagre data available, a "safe" distance is difficult to establish. Disturbance definitely occurs within one mile, and may occur up to five. As may be seen from the Figure, a five-mile length of the proposed route (Mile 390 to 395) lies within one mile of the important winter and lambing areas. A 35-mile length (Mile 371 to 406) lies within five miles of these areas plus the more extensive winter range area, and this length contains the following facilities: communications tower CA-08A, three heliports, two to four borrow pits and one staging site. None of these facilities, however, lies within the highly critical wintering and lambing areas running from Mile 390 to 395 (*see* Figure).

As sheep, particularly lambs and pregnant ewes, become more susceptible to disturbance and displacement as the spring approaches, construction between Mile 371 and 406, and especially between Mile 390 and 395, would be less harmful if it took place early in the winter, i.e. before the late-pregnancy and lambing period.

Exploitation

The Northwest Territories sheep harvest in the Richardson Mountains is closed to sport hunters, but 30 to 60 animals are taken annually on general hunting licences and contribute to the meat diet of the native population, primarily in Aklavik. Both Simmons (1973) and Jakimchuk *et al.* (Biol. Rept. Ser. Vol. 4) consider this harvest has passed its desirable ceiling and has been excessive for most of the past six years. This, combined with the fact that there is a potential demand for heads and hides in southern markets, places the population in a precarious position, when the pressures of pipeline development are also superimposed. An urgent need is seen, therefore, for a more comprehensive monitoring and study program to understand population trends better and, if necessary, to suggest measures to ensure the continued existence of the species.

Although open to sport hunters the Firth River population is not currently exploited. If increased access puts pressure on the population, its behaviour and dynamics will also need

understanding to ensure its survival.

Highlights

1. Dall's sheep inhabit the wilderness areas of northwest America and are highly sensitive to disturbance. The Mount Goodenough population, already under pressure by hunting, could well be further stressed by the pipeline development in the area east of the Richardson Mountains. Here there is a very narrow strip of land between the mountains and the Mackenzie Delta and the only feasible pipeline route passes close to the sheep's highly sensitive wintering and spring lambing areas (*see* Figure).

2. Noise from aircraft operating both along the pipeline route from Mile 371 to Mile 406, and west of this over the sensitive areas, could displace the sheep from their normal habitat and lead to greatly increased mortalities. The problem could be substantially reduced if:

(i) fixed-wing air traffic along this stretch of the route and west of it were kept to a minimum during the sensitive season from October 15 to June 15, particularly January 31 to June 15;

(ii) essential overflights by fixed-wing aircraft along the stretch of the route and west of it, between October 15 and June 15, were made above an altitude of 2,000 feet above ground;

(iii) low-flying helicopters were to stay out of the sensitive areas west of the pipeline route from Mile 371 to 406 from October 15 to June 15, and were to stay east of the pipeline route from Mile 390 to 395 during the period January 31 to June 15.

3. Noise from construction and associated activities along the route between Mile 371 and 406, and especially between Mile 390 and 395, could be as damaging to sheep within the latter mileages as the dangers outlined above arising from aircraft noise. This problem could be greatly reduced if: (i) so-called "winter" activities in the above areas were to take place as early in winter as possible, i.e. prior to January 31 (before the critical period); (ii) so-called "summer" activities were to take place after June 15 (after lambing).

4. Although the sensitivity of Dall's sheep to noise is established, the implications of the long-term behavioural and psychological responses to noise are not well understood. If appropriate behavioral studies of the sheep's response to stress were undertaken before pipeline construction they could assist in refining the protective measures needed.

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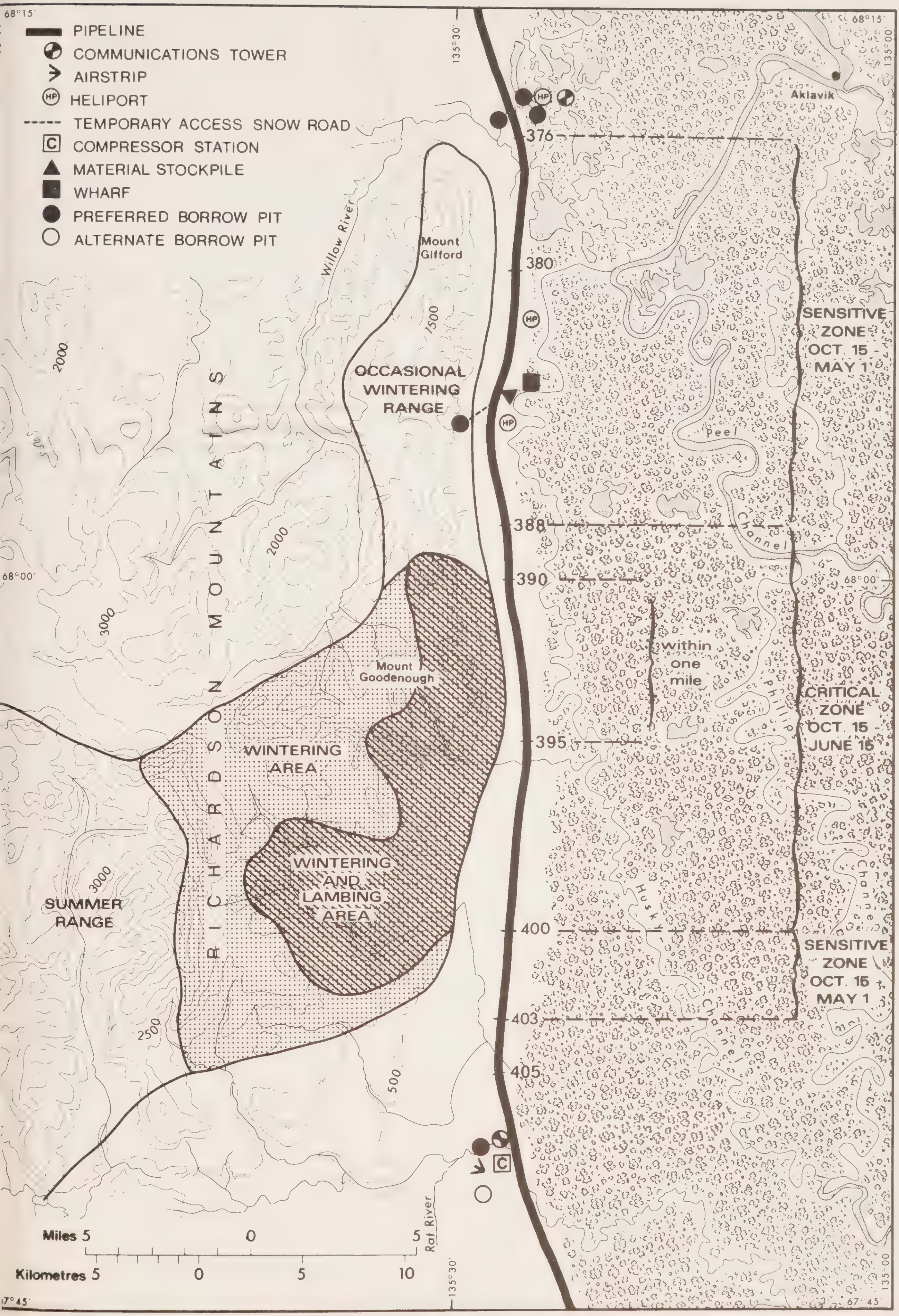

nter and summer ranges and critical lambing area of the Mount Goodenough Dall's sheep in relation to the
ime Route of the proposed pipeline. (After Nolan, 1974).

9.3 SNOW GEESE

Introduction

Few species of wildlife have come to be identified with a country so characteristically and intimately as geese have for Canada. Heralding annually the advance and decline of the seasons, the inimitable flights of these majestic birds enjoy an almost legendary and emblematic national and international status. Of the several different species, the one that specifically concerns us relative to the gas pipeline is the Lesser Snow Goose (*Chen caerulescens*). Protected by the Migratory Birds Convention Act, it serves also as an important food and recreation resource. From the Mackenzie Delta, through southern Alberta and Saskatchewan, to the mid-west of the United States, hunters eagerly seek it each fall.

Concern for the viability of the birds arises because pipeline development is proposed through critical segments of their main migratory route. Flocks are extremely susceptible to disturbance and their time-table is so tight that even natural phenomena may impose a stress. A late spring, for example, could vitiate the year's production of young; hence combinations of man-made and natural stresses could severely reduce the breeding population. Of particular concern is the situation on the Yukon North Slope because the construction and operation of the pipeline here might disturb resting and prevent the building-up of the birds' energy reserves for the long fall migration. Aspects of this have already been included in "Requests for Supplementary Information" (#48). In the following sections the Assessment Group elaborates its concerns and indicates ways in which the Applicant's generally sound procedures might be further strengthened to ensure no harmful impact upon the birds.

Applicant's and Other Data

The basic biology of the snow goose is as follows. Each spring, thousands of birds return from their wintering areas in the southern United States by way of the Mackenzie River valley. They require open water, and they rest, feed and mate on the partly flooded river islands and on nearby lakes after the break-up of the river ice. Their destinations are the few suitable nesting areas at the mouths of the Anderson and Smoke Rivers (Northwest Territories), Banks Island, and a few small scattered sites near the marine interface of the Mackenzie Delta. Snow geese are colonial nesters, returning each year to the same areas. Such areas have extensive brood-raising capabilities.

By mid-August the geese gather on the islands of the Delta in flocks of some 20,000 to 50,000 birds totalling 500,000 in some years. They then fly westward to the North Slope of the Yukon Territory and Northeast Alaska. Here they feed intensively on berries and sedges for four to six weeks to prepare themselves for the long migration to the wheat fields of southern Alberta and beyond. They usually fly non-stop the 800 miles between the North Slope and Hay Lake in northern Alberta (Barry, 1967).

Because of the shortness of the northern summer, the available nesting season is short, with barely enough time to raise young to flight size before the fall freeze-up. Interruption of the birds' normal movement and behaviour patterns, especially their energy-building feeding period in late summer, could mean that both adults and juveniles might not have the stamina to complete their southward migration.

The specific studies sponsored by the Applicant recognize most of the environmental problems associated with snow geese (Gollop & Davis, 1974; Schweinsburg, 1974). Simulated compressor-station noise was shown to disrupt the birds' movement patterns, and birds as far as three miles away from the source of noise were displaced. Eventually, however, some birds returned to within 1.5 miles of the noise source. These results have prompted the Applicant to propose special measures to muffle the sound emissions from the two compressor stations CA-04 and CA-05 at Demarcation Bay and Malcolm River on the Yukon North Slope. These stations are critically located because less than 20 miles separates the coast and the mountains (Sect. 14.d.N. 7.8.1, p.38).

The Applicant recognizes that aircraft are extremely disturbing to resting snow geese. He proposes, therefore, to "...avoid overflying the locations of known concentrations of geese and will make every effort to avoid overflying concentrations discovered en route." (Sect. 14.d.N.7.8.1, p.40). Moreover, although this precaution is primarily intended for the North Slope geese-staging area between 15 August and 30 September, the Applicant extends the precaution by stating "Barrier beaches, lagoons, tundra lakes, islands in the Mackenzie River, and nesting sites of ... colonial species will be avoided during times when they are occupied by birds." (Sect. 14.d.N.7.8.3, p.46). As winter construction will not commence until snow geese and other waterfowl have migrated, no conflict is seen (Sect. 14.d.N.7. 8.1, p.37).

Similarly, the Applicant indicates "... work on the right-of-way will be ended prior to the birds' return in the spring." (Sect. 14.d.N.6.3.6.b, p.10).

Concerns

Applicant's Coastal Staging Operations

Although the Applicant indicates concentrations of snow geese at their staging areas will not be disturbed, a problem may arise from potentially disturbing unloading and pipeline-staging activities on the North Slope in late August and early September. Concern arises because two different viewpoints are expressed on the birds' whereabouts. On the one hand, it is said that pipeline-staging sites will be located in areas of lesser sensitivity (Sect. 14.d.N.7.8.1, p.41), thereby implying appreciable variation in the birds' distribution; but elsewhere (Sect. 14.d.N.4.8.3, p.73) it is stated that the geese "...scatter all over slope, moving inland as far as and into foothills.", suggesting a more even distribution. One wonders, therefore, how well understood are the critical areas that have to be avoided. It is probable that further studies could assist. From observations made in 1973, Poston (pers. comm.) believes that geese use specific areas at specific times. If these behaviour patterns were better established, it might be possible to optimize the design and location of each pipeline facility so that the least possible disturbance occurred.

Aircraft Disturbance

Studies carried out by the Applicant demonstrate the extreme sensitivity of snow geese to aircraft noise (Sect. 14.d.N.7.8.1, p.40) and on the basis of the extraordinarily long distance of nine miles over which feeding flocks were disturbed by a light aircraft, one could envisage that on occasions not much of the 20-mile strip between the sea and the British Mountains would remain satisfactory for the geese. Although this topic is discussed more fully elsewhere (*see* topic "Harassment by Aircraft"), it may be said here that particular

attention to the planning and enforcing of flight restrictions is required during the main operational phase of the pipeline development for the two to three flights a week indicated for the North Slope.

Compressor Stations

As indicated above, the Applicant proposes special measures to abate noise emissions from stations CA-04 and CA-05 at Demarcation Bay and Malcolm River respectively. Concern arises, however, in respect of stations CA-06 and CA-07 at Babbage River and Shoalwater Bay respectively, for these also lie within the geese-staging area. To the Assessment Group, it does not seem adequate to suppose the wider coastal belt here will permit the geese to avoid the area of noise surrounding these stations. As explained above for staging operations, better information on the birds' behaviour pattern would permit these stations' noise-suppression measures to be more rationally designed.

Winter Construction

There is considerably more variation in the time of departure of the flocks migrating from the North Slope than the Applicant's one-year study has recognized. In 1966, for example, an unusually mild fall delayed departure until 12 October (Barry, 1967). A more prudent basis for the planning of pipeline activities, therefore, would be to assume the geese occupy the area from mid-August until mid-October, rather than until 30 September.

Kendall Island Migratory Bird Sanctuary

Comparison of the boundaries of the Kendall Island Migratory Bird Sanctuary (Migratory Bird Sanctuary Regulations) with the Applicant's proposed right-of-way shows that the Richards Island terminal falls inside the Sanctuary. In contrast, the Applicant's smaller-scale Wildlife Series Maps show that the terminal is outside, although the associated borrow pit is shown in the Sanctuary. Parts of the Sanctuary are used by snow geese for breeding, moulting and fall-staging (Barry, pers. comm.) and the development of a pipeline terminal, together with the gas production and gathering system and associated noise and activity, could have a profound adverse impact on the use of these areas by the geese. The Sanctuary cannot be entirely avoided, of course, because it contains part of the gas field, and some collecting and processing facilities are bound to be developed there by the producers if the field is tapped. Industry is already in the Sanctuary under permit by the Canadian Wildlife Service. The solution to a possible conflict between geese and the development appears to lie in locating the production facilities so that sensitive geese areas are avoided, or where this is not possible, in employing operating procedures that are acceptable to the appropriate regulatory agencies. Constraints that may be placed on location of components of the production system, of course, could change the location of the pipeline terminal.

Highlights

1. Geese are one of the more outstanding and characteristic wildlife species of Canada. The proposed pipeline development is in potential conflict with one variety, the Lesser Snow Goose, because when the birds are building up their reserves on the resting and staging areas before migrating southward, they are highly sensitive to disturbance.

2. The Applicant has recognized most of the problems that could arise from the potential for conflict and has in general designed procedures that go a considerable way towards avoiding disturbance of the geese, especially on the Yukon North Slope.

3. For example, careful planning and strict enforcement of the safety rules designed for aircraft flights should minimize disturbance of the geese, especially on the Yukon North Slope.

4. Again, winter construction by the Applicant will usually avoid the possibility of pipeline activities disturbing geese, but the fact that in some seasons the geese will not have left the North Slope until mid-October instead of the more normal 30 September requires consideration in scheduling pipeline activities.

5. In the design of both the Applicant's coastal staging procedures and his noise-suppression measures at compressor stations, the Assessment Group feels that more optimal and reliable pipeline practices will be achievable if studies can be continued to provide fuller information on the birds' movements and behaviour patterns. More sensitive locations might be avoided or noise emissions further abated.

6. The northern terminal of the Richards Island branch of the pipeline, at the southern edge of the Kendall Island Bird Sanctuary, will connect to gas production facilities in the Sanctuary. Any adjustments to the location of the latter that may be made to protect geese may perhaps lead to relocation of the terminal.

Literature Sources

Barry, T.W., 1967. "The Geese of the Anderson River Delta, N.W.T.", Ph.D. Thesis, Univ. of Alberta, Edmonton, Alta.

Gollop, M.A. and R.A. Davis, 1974. "Gas Compressor Noise Simulator Disturbance to Snow Geese, Komakuk Beach, Yukon Territory, September, 1972", *in* Biol. Rept. Ser., Vol. 14, Ch. VIII, prepared for Canadian Arctic Gas Study Ltd.

Schweinsburg, R.E., 1974. "Snow Geese Disturbance by Aircraft on the North Slope, September, 1972", *in* Biol. Rept. Ser. Vol. 14, Ch. VII, prepared for Canadian Arctic Gas Study Ltd.

9.4 ENDANGERED BIRDS OF PREY

Introduction

Northern Canada is widely recognized to be one of the last major refuges for many species of North American raptors. Highly sensitive to the disturbance and development associated with man, the numbers of these birds of prey have decreased drastically in central, southern and eastern North America. Both the purely wilderness species—Gyrfalcon (*Falco rusticolus*) and Golden Eagle (*Aquila chrysaetos*)—and the normally more widely distributed species—Peregrine Falcon (*Falco peregrinus*), Merlin (*Falco columbarios*) and Bald Eagle (*Haliaeetus leucocephalus*)—have been the victims of toxic chemicals, falconers, egg collectors and hunters, to the extent that the Peregrine, for example, is today in danger of extinction. Surviving populations of these species in northern Canada are in some way unique therefore, and in consequence are both nationally and internationally important. They are protected under the Game Ordinances of the Territories and Provinces, and their export from Canada is prohibited under the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Furthermore, to aid their conservation the Canadian Wildlife Service does not reveal publicly any information on the whereabouts of nesting sites.

Environmental concern arises because the proposed gas pipeline route passes through wilderness areas that provide nesting sites and breeding habitat for these birds. The potential for conflict is two-fold: nests and nesting sites may be destroyed; and the disturbance of pipeline activities may drive birds from their young, from their nests, or from their living space (habitat).

The difficulty of avoiding such conflicts is complicated by the need to avoid public disclosure of location of nest sites and the lack of precise knowledge of the minimum distance required to prevent disturbance. The latter aspect is further complicated by most of the species being migratory. The critical nesting period begins around mid-April and may extend to the end of August (Fyfe and Kemper, 1974). In some years, however, Gyrfalcons may spend the entire winter in the vicinity of the nest site and begin nesting in early February. Young are usually fledged by the end of July, but this varies greatly (Cade, 1960).

The Applicant has recognized the necessity of identifying nesting sites and of avoiding them by a suitable distance in locating the pipeline and its ancillary facilities (Sect. 14.d.N.6.3.6, p.10). However, it is not clear whether the procedures proposed can sufficiently protect the birds, especially during their sensitive period. This deficiency in the information provided has already been the subject of a request to the Applicant for Supplementary Information (#51). Although the following review cannot discuss specific locations and must remain more at the level of generalities and principles, an attempt is made to present the environmental concerns and to indicate procedures that could assist in the survival of these endangered birds.

Applicant's and Other Data

To understand adequately the environmental concern centred on the birds' nesting sites it is first necessary to explain how exacting are the biological requirements of the species and how few are the places that can fulfill them. The species involved fall into two groups: the tree-nesters, such as the Bald Eagle; and the cliff-nesters, such as the Peregrine Falcon, Gyrfalcon, and Golden Eagle. Both groups, of course, must have

suitable nesting sites and adjacent food supplies. This combination is usually scarce, in some areas trees are plentiful, but fish—the major food of eagles—are limited, because only certain water-bodies are suitable sources. These are the outlets or shores of large rather shallow lakes, such as Trainor, Trout, Chick and Travaillant Lakes, or the many lakes in the Mackenzie Delta.

Similarly, the mountainous areas possess numerous cliff faces but few have nearby sources of ducks and shorebirds favoured by Peregrine Falcon, or of ptarmigan and hares favoured by Gyrfalcons. The rare combination is found in parts of the Richardson Mountains and the Norman Range where abrupt cliffs tower above adjacent lowlands. This habitat can also occur along river valleys, certain stretches of the Mackenzie and its tributaries and the rivers of the Yukon North Slope. Territorialism of the birds themselves further restricts their use of available habitat. Nesting pairs are normally more than two miles apart, and a single pair of some species may use alternate nest sites through the scarcity of prey. An apparently empty nesting site, therefore, does not necessarily signify a surplus of sites that are expendable.

Turning now to specific studies, we may first note the annual surveys of raptor nesting sites carried out since 1964 by the Canadian Wildlife Service (CWS) in the Western Arctic. Those of 1972, 1973 and 1974 focused on the proposed pipeline route (Fyfe and Kemper, 1974). Surveys were also made by the Environment Protection Board in 1972 and 97 sites were discovered. The detailed results of these and most other raptor surveys are maintained by the CWS in Edmonton, but the locations of sites are not publicly divulged. Disturbance data are not plentiful (Watson *et al.*, 1973; Fyfe and Kemper, 1974) but have permitted the formulation of tentative guides to precautionary measures. Until additional data become available to refine these guides they represent the most authoritative that can be adopted. Little is known on the basic biology of Arctic raptors (Cade, 1960), but this subject is currently under study.

The Applicant has also made several surveys of the pipeline route to identify raptor nesting sites, and indicates that "Known nesting sites were avoided in the pipeline alignment." (Sect. 14.d.N.7.8.2, p.43). In addition, studies are continuing that might reveal additional sites and necessitate re-alignment. Where re-alignment is not possible the Applicant proposes the scheduling of activities to minimize impact during critical periods. Areas containing raptor breeding sites known to the Applicant have been shown on the Applicant's Alignment Sheets and Corridor Wildlife Maps.

Concerns

Conflict With Nest Sites

Considerable lengths of the proposed pipeline right-of-way and an appreciable number of its ancillary facilities fall within areas classified as containing the breeding habitats of rare and endangered birds. The Applicant has acknowledged that 16 raptor nests are so affected along the coastal section of the Prime Route (Sect. 14.e.1. 2.3.2.b.(iii), p.115), the right-of-way passing within less than three miles from them, but has not indicated the fact that over 100 miles of pipeline alignment, three compressor stations, 12 borrow pits, one staging-site, one communication tower, three helipads, and three airstrips can also be seen from the Corridor Wildlife Maps to fall within similarly classified areas. Whether nesting raptors are threatened by these proposals remains uncertain.

Three main reasons give rise to this uncertainty. First, the Applicant indicates that he has or will avoid nesting sites, but adds the rider "where possible", which seems to weaken the assurance. Secondly, he has not defined what is meant by "avoid". A distance acceptable to the Canadian Wildlife Service (Fyfe, pers. comm.) is specified in the Applicant's discussion of the Interior Route, viz., "construction within at least 2.5 miles of nesting cliffs should be avoided" (Sect. 14.e.1.2.2.2.b.(iii), p.82), but there is no indication that this distance will be applied in alignment adjustment along the Prime Route. Thirdly, where relocation to avoid a raptor-nest site is not possible and pipeline activities are to be minimized by the Applicant during the critical nesting period, it is not clear whether this minimized activity will apply out to the limits of the sensitive (2.5-mile) distance from the nest.

Critical Nesting Period

The Applicant's treatment of the critical nesting period raises some concerns. Only in the discussion of the Interior Route and on the Alignment Sheets are dates for this period provided. Thus, "From the point of view of such birds, construction within at least 2.5 miles of nesting cliffs should be avoided between March 1 and August 15 ..." (Sect. 14.e.1.2.2.2.b.(iii), p.82). However, only in a general way can these dates be defended, because for most species the critical nesting period begins around mid-April and terminates at the end of August (Fyfe and Kemper, 1974). Moreover, Gyrfalcons may spend the entire winter in the vicinity of the nest site, then commence nesting in early February. Their young are usually fledged by the end of July, but this varies greatly (Cade, 1960).

It is with Gyrfalcons that most scheduling problems arise. They nest north of the tree line, where the numerous operating difficulties may make it particularly awkward to halt construction activities as early as February 1. In this instance, as with the other raptor species, avoidance of the nesting sites by the 2.5-mile safety distance is favoured over the proposed scheduling.

Disturbance by Aircraft

This is reviewed more fully elsewhere (*see* topic "Harassment by Aircraft"), where it is shown that serious disturbance can occur from low-level flights made near the nesting sites. The period April 15 to August 31 is particularly critical, except for Gyrfalcons when it starts on February 1. Disturbance can be reduced by ensuring that aircraft passing within 2.5 miles of a nesting site are not less than 1,000 feet from ground level.

Permanent Pipeline Facilities

The establishment and operation of such permanent facilities as compressor stations, airstrips and communication towers will necessitate an increased level of human activity and associated disturbance. In addition to the direct threat of disturbance to the raptors there is an indirect one occasioned by the human disturbance of their prey species. Scheduling to avoid critical periods is, in the case of these facilities, impractical. As these birds are wilderness species and not accustomed to human disturbance, they are likely to abandon their nests when continuously or repeatedly disturbed. The satisfactory solution, therefore, is to locate such permanent facilities at least 2.5 miles from raptor nests.

Borrow Pits

Borrow pits are particularly disruptive to nesting raptors because of blasting, the noise of

equipment, and the destruction of nests. Harm can be minimized, however, if pits are either selected more than 2.5 miles away from nesting sites, or where this is not possible, if operations are scheduled outside nesting periods.

Highlights

1. Northern Canada is one of the last major refuges for several important species of North American birds of prey. Such species are very prone to abandon their nests or young when disturbed by man or noise, hence pipeline development poses a threat to them.

2. Because, for reasons of conservation, locations of raptor nesting sites are not divulged to the public, a detailed portrayal and review of the threat, together with suggestions for site-specific measures for the alleviation of the problem, have not been possible. In general terms, however, over 100 miles of the proposed pipeline alignment and numerous ancillary facilities are located in areas classified as containing the breeding habitats of rare and endangered avian species.

3. The Applicant proposes that the pipeline alignment and associated facilities avoid raptor nest sites and, where this is not possible, he proposes the scheduling of activities to minimize impact during sensitive nesting periods.

4. The difficulty for the Assessment Group has been that the distance of avoidance and the sensitive nesting periods are defined by the Applicant for the Interior Route but not for the Prime Route.

5. For the Prime Route, the Assessment Group would accept the 2.5-mile minimum distance specified by the Applicant for the Interior Route as adequate for protection. Furthermore, where such a separation is not possible, the scheduling of operations outside the period February 1 to July 31 would be satisfactory for Gyrfalcon, and outside the period April 15 to August 31 for other raptors.

6. Protection from aircraft disturbance could be achieved if all flights made within 2.5 miles of nesting sites were not less than 1,000 feet from ground level.

7. Because the 2.5-mile minimum distance is a conservative precaution, it is suggested that in preparing his final design the Applicant work closely with the appropriate Regulatory Authority on a site-by-site basis. In this way, the optimum practical solution both for the existing and yet to be found nesting sites should be possible.

Literature Sources

Cade, T.J., 1960. "Ecology of the Peregrine and Gyrfalcon Population in Alaska", Univ. Calif. Publ. in Zoology, Vol. 63, No. 3, pp. 151-290.

Fyfe, R.W. and J.B. Kemper, 1974. "Endangered Raptor Breeding Territories near the Proposed Mackenzie Valley Gas Pipeline Route and Recommendations for Their Protection", Preliminary report prepared for the Task Force on Northern Oil Development, Ottawa.

Watson, G.H. *et al.*, 1973. "An Inventory of Wildlife Habitat of the Mackenzie Valley and Northern Yukon", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-27.

9.5 HARASSMENT BY AIRCRAFT

Introduction

Many species of wildlife in northern Canada are disturbed by the intrusion of aircraft. The disturbance stems not only from their noise but also from their reverberations and visible presence. As might be expected, degree of disturbance depends upon the type of aircraft, its speed, direction, altitude and lateral distance and can vary with climatic factors, such as temperature, cloud cover and humidity. Moreover, different species of animals and birds vary in their tolerance, of which previous exposure to aircraft can be a factor. Disturbance effects can be highly critical to the viability of a population of animals or the species itself. Displacement from areas where species traditionally feed, gestate or raise their young can interrupt a tightly scheduled pattern of activity that is necessary for continued well-being of the population.

General environmental concern arises because aircraft play an important part in the Applicant's proposals. Aircraft will be used for the transportation of men and materials in all stages of the natural-gas pipeline development for the completion of a host of tasks. They will be used in the preparation of pre-construction surveys, for a variety of tests and studies, for construction, operation, maintenance, surveillance, monitoring, and probably for abandonment and inactivation. They will be particularly indispensible for contingencies and for facilitating emergency repairs. Moreover, as is explained in Section 13.b.3.2, aircraft will be both large and small, fixed-wing and helicopters.

Specific environmental concerns arise in respect of certain animals and birds, in certain sensitive geographical areas or habitats, by reason of various proposed aircraft traffic schedules and proposed altitudes. In the case of wildlife species that have been considered important enough to warrant topic reports entirely devoted to them—and this includes the "Porcupine Caribou", "Dall's Sheep", "Snow Geese" and "Endangered Birds of Prey"—harassment by aircraft is reviewed in these topic critiques, along with other types of disturbance. In the present topic harassment concerns are brought together in one place and species are included and specifically mentioned that are not the subject of separate topic reports. These species are barren-ground grizzly bear, moose, whistling swans, osprey and whooping crane, and especially geese and ducks. Numerous other species are not specifically mentioned, such as woodland caribou, Arctic fox, wolves and smaller birds, but they have been considered by the Assessment Group and no threat to them is seen by normal aircraft operation. The situation would be very different, however, if aircraft were permitted to harass them deliberately or if aircraft were used to hunt them. Below, the Assessment Group elaborates its concerns and concludes that most threats to wildlife by aircraft could be minimized by strict adherence to certain minimum height and operating constraints.

Applicant's Data

The biological studies sponsored by the Applicant have enabled him to recognize the potential aircraft have to disturb specific species of wildlife. He has stated as summarizing remarks that: "Guidelines for operational and logistic aircraft movements, particularly regarding minimum altitudes and direction of approach to landing strips, will be established to reduce this type of disturbance" (Sect. 14.d.N.2.2.4, p.13). In addition, in a particular paragraph concerned with the impact of aircraft on waterfowl on North Slope Lakes, he makes a remark of widespread significance, *viz*., that "...(he) does not plan ... to use float-

equipped aircraft during any phase of pipeline activity" (Sect. 14.d.N.7.8.1, p.39).

In a more specific way, the Applicant describes in a number of places in the exhibits his proposals for avoiding sensitive geographical areas. These include the wintering and lambing areas of Dall's sheep on the Mount Goodenough slopes of the Richardson Mountains (Sect. 14.d.N.7.9.3, p.52), the valleys of the northern foothills and Yukon coast frequented by barren-ground grizzlies in summer (Sect. 14.d.N.7.9.4, p.52), areas on the Arctic coast and Lower Mackenzie Delta used by waterfowl, moulting sea ducks and feeding snow geese (Sect. 14.d.N.7.8.1, p.39), and a variety of sites from the Delta to 60 degrees North used by spring and fall migrating waterfowl, especially whistling swans (*Olor columbianus*) and snow geese (*Chen caerulescens*), and by rare and endangered avian species, including the golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaetus leucocephalus*), osprey (*Pandion haliaetus*), peregrine falcon (*Falco pereginus)* and whooping crane (*Grus americana*) (Sect. 14.d.N.7.8.2, p.43).

Protection measures are described for mammals: "Deliberate or inadvertent aircraft ... harassment of wildlife will be minimized during construction and operation through controls on flight plans (direction and ceiling) ..." (Sect. 14.d.N.6.3.7, p.11), and for birds: "Aircraft altitude, flight-path and scheduling will be strictly controlled to avoid or reduce disturbance to birds, especially snow geese and raptors" (Sect. 14.d.N.6.3.6, p.10).

Specific minimum flight altitudes have been proposed for aircraft flying over Porcupine caribou (1,000 ft), moose (1,000 ft), grizzly bears (1,000 ft), concentrations of waterfowl (1,000 ft), feeding snow geese (1,000 ft), and birds of prey (1,000 ft, but only the Interior Route specified) (Sects. 14.d.N.7.8.1; 14.d.N.7.9.1; 14.e.1.2.2.2.b (iii), p.82; and Vol. 5, Biological Report Series).

Concerns

Winter and Spring Disturbance

Except for some tundra lakes, islands in the Mackenzie River, nest sites of rare and endangered bird species and some winter concentrations of moose, almost all the concern arising from the operation of aircraft is centred on the North Slope of the Yukon and in the area immediately west of the Mackenzie Delta. Most of this concern relates to possible aircraft disturbance in summer and fall, but some relates to the winter and early spring when the Mount Goodenough Dall's sheep population is concentrated in its traditional overwintering and lambing areas; moose concentrate their movements in the North Slope river valleys; there are unusual winter movements of caribou herds, and some raptor species nest early. As the major construction program for the pipeline is to take place in winter, some harmful disturbance from aircraft traffic seems inevitable unless special precautions are taken. Moreover, Dall's sheep, moose and caribou could all suffer more harm from disturbance or displacement from their habitats as the winter advances, and when severe weather has physically weakened the animals particularly pregnant females. The potential for harm increases as the winter progresses and is accompanied by increased need for protective measures. Fortunately, however, the location of the sensitive winter-areas for Dall's sheep and moose are known, and the movements of caribou herds can be monitored by aircraft (at a discrete distance). For moose and caribou a minimum aircraft altitude of 1,000 ft above ground level could avoid harmful disturbance. Both the Applicant and others (DeBock and Surrendi, 1974) have advocated this minimum height. For the more sensitive Dall's sheep, a minimum aircraft altitude of 2,000 ft appears to be needed to reduce hazards; additional critical periods and locations for aircraft relative to the Mount Goodenough sheep population are recorded in the topic "Dall's Sheep".

Summer Disturbance

Gyrfalcons, the earliest of the rare raptors to nest in the north, may sometimes spend the entire winter in the vicinity of their nest sites. They may occupy nesting territory as early as February and begin laying eggs early in April. Unfortunately, gyrfalcons are acutely sensitive to aircraft and it is in the early part of the nesting period when most damage can be done (Fyfe, pers. comm.). Fortunately, a fair number of the gyrfalcon nesting areas along and near the pipeline route are known and others could be located by the final design stage. A minimum altitude of 1,000 feet above ground-level for aircraft passing within 2.5 miles of a nesting site should avoid disturbance for all raptors. The period April 15 to August 31 is critical for all raptors, but in the case of gyrfalcons the critical period begins on February 1.

Along the Yukon North Slope where the Prime Route is proposed, the operation of aircraft during the summer and fall (May 1 to October 30) could adversly affect the summer movements and calving of caribou, the movement of grizzly bears, the lambing of Dall's sheep, the nesting and staging of waterfowl, and the nesting of rare and endangered birds of prey. Most of these problems could be alleviated or perhaps eliminated by avoiding overflying concentration areas of these species during sensitive periods and by flying higher than 1,000 feet above ground-level (2,000 ft for Dall's sheep) at all times. It must be remarked, however, that Dall's sheep and staging snow geese are highly sensitive species and minimum altitudes that can guarantee no disturbance are not yet well established. In some seasons snow geese on the North Slope do not leave their staging areas until mid-October, instead of late September as normally. If this were taken into account in the Applicant's scheduling of pipeline activities, particularly from Mile 195 to Mile 320, harm at this time could be reduced. Available evidence (Salter and Davis 1974) suggests the distance over which snow geese can be disturbed by aircraft is far larger than would be thought possible. Thus there is particular concern over aircraft disturbing snow geese on the North Slope from August 15 to October 15. Any possible measures for limiting aircraft use during this period would be worthy of study.

Other North Slope Concerns

The operation of two to three flights per week on the North Slope for pipeline construction and operation and the avoidance of snow geese concentrations as proposed by the Applicant (Sect. 14.d. N.7.8.3, p.40) would appear to afford appropriate protection, provided the minimum flying altitudes are adhered to. Little is known about the longer term effects of regular aircraft flights, and monitoring in this regard would be useful to refine or modify the precautionary measures.

Other Mackenzie Valley Concerns

In general the flight-control arrangements proposed by the Applicant that delineate flight corridors along the Mackenzie River and specify minimum flying altitudes appear satisfactory to avoid disturbance. However, at Brokenoff Mountain where the pipeline route and highway go through a narrow pass in the mountains, low-level aircraft would disturb raptors nesting in or near the pass. In this area regular pipeline inspections might be made from the nearby highway rather than by aircraft.

Airstrips and Helipads

The locations of airstrips and helipads could generate problems if approaching or departing aircraft pass low over nearby sensitive areas.

The additional noise at take-off could be particularly disturbing. The airstrip at the Malcolm River, next to Compressor Station CA05, is an example involving concern over disturbance of nesting raptors (*see* "Requests for Supplementary Information"). This kind of hazard could be avoided or reduced by adjustments in airstrip location.

Highlights

1. Wildlife can be readily disturbed by the intrusion of aircraft and the precarious existence of several important species in the area of pipeline development aggravates this threat to their viability.

2. Among the mammals Dall's sheep, caribou, barren-ground grizzly bears, and moose are sensitive to normal aircraft operation, but many more species including wolves and Arctic fox could be seriously threatened by deliberate harassment or hunting from aircraft. Among the birds, gyrfalcon, golden eagle, peregrine falcon, merlin, bald eagle, whistling swans, osprey, and whooping crane are sensitive, and especially other species of waterfowl including geese and ducks.

3. Harmful disturbance by aircraft could be minimized for most species if air-traffic corridors are established and if minimum flying heights are adopted. Necessary, too, would be strict implementation of these constraints. It would be important, too, to take traditional wildlife concentration areas into consideration in the location of airstrips and helipads, so that use of these facilities does not require aircraft to approach or take-off over sensitive wildlife areas. It will be important to identify sensitive areas in terms of location and time for reference in control of aircraft.

4. For most species, harmful disturbance could be avoided if aircraft were to fly not less than 1000 ft above ground level and avoid concentration areas of animals or birds. In the case of the highly sensitive Dall's sheep and snow geese, however, a minimum aircraft altitude of 2000 ft seems a safer figure with the added provision of minimizing all flights at critical periods of the year and at critical locations. A particularly sensitive area is the Yukon North Slope between May 1 to October 30.

5. The special sensitivity of some species of wildlife on the Yukon North Slope and certain other locations combined with the limited nature of the information on certain species' sensitivity to disturbance and pattern of movement point to the value of further studies to aid in refining precautionary measures.

Literature Sources

DeBock, E.A. and D. Surrendi, 1974. "Some Aspects of the Ecology of the Porcupine Caribou Herd", Prelim. Rept. prepared for the Task Force on Northern Oil Development, Ottawa.

Salter, R. and R.A. Davis, 1974. "Snow Geese Disturbance by Aircraft on the North Slope, September, 1972", Canadian Arctic Gas Study Ltd., Biol. Rept. Ser. Vol. 14.

9.6 FRESHWATER AQUATIC ECOSYSTEM SENSITIVITY

Introduction

To understand and assess the impact pipeline development might have upon plants and animals in the north requires—as is obvious from the Application and this Review—a wider look than the plants and animals themselves. Their setting must be studied, with its climate, soil, habitat characteristics and so forth. So it is with fish, but in this case their setting is the lakes, rivers and streams where they live. The study of their well-being has significance only if the factors controlling it are also studied. This includes such aspects as the supply of smaller food organisms, dissolved-oxygen concentration, the levels of dissolved minerals, the degree of siltation, the presence of noxious substances and so forth. As might be imagined this aquatic world is as complex as the terrestrial one, so that freshwater biologists use the term "aquatic ecosystem sensitivity" to describe the complex interactions involved and the degree to which they can withstand introduced impacts.

Unfortunately, the present knowledge of aquatic ecosystems in northern Canada is limited in spite of a recent upsurge of interest. Much more is known about southern aquatic ecosystems but their different characteristics mean that not much can be extrapolated to the north. The growing season for aquatic plants and animals is very short because of the long period of ice cover and low water temperatures; and the supply of nutrients in the water is small. The biological time scale is lengthened when compared to that in southern latitudes, so that fish and other organisms in the water grow more slowly and mature later. For example, planktonic crustaceans in southern latitudes produce several generations in one year but in the North these require one or two years for a single generation; some populations of Arctic char may take up to twelve years to reach maturity in northern waters.

The northern ecosystem contains few species; small disruptions could cause great changes in plant and animal populations. For example, whitefish taken by Native fishermen are composed of several year classes. The loss of one year class might be filled in by younger or older fish with little effect to harvesting success in the long run. But if a species were eliminated by overfishing or by pollution, lasting changes could be produced from even short-term disruption. If the disruption occurred in the headwaters of a river system containing abundant populations of benthic organisms which serve as a reservoir to re-colonize disturbed areas downstream, the productivity of the entire system might be in jeopardy.

In assessing the impact or probable impact of a project, the existing natural situation must be characterized. For example, addition of small quantities of silt to tributaries entering the Mackenzie River from the west may not be harmful as streams are normally turbid, whereas, the same amount of silt added to the eastern tributaries may be extremely harmful at those times of year when they are clear.

Pipeline development and related activities pose threats to the northern aquatic ecosystem through silting, spills of fuels or other toxic fluids, organic pollution (enrichment of waterbodies by addition of nutrient-rich sewage effluents), gravel and water extraction and overharvesting of fish. Erosion of valley walls can lead to the silting of fish spawning beds, the blockage of fish migrations to or from spawning, feeding or overwintering areas and the smothering of fish eggs and benthic organisms. If gravel is removed from river courses or active flood plains, spawning beds could be destroyed or channels and back eddies, important nursery areas for young fish, physically destroyed or rendered unproductive by a layer of silt. Below,

the Assessment Group elaborates on the various ways in which environmental concerns can arise in aquatic ecosystems through the various activities associated with pipeline development.

Applicant's Data

In his description of the environmental setting of the proposed pipeline route the Applicant has not discussed the complete aquatic ecosystem but rather has directed his comments towards fish. He has used data from his own field studies and from government and other sources to discuss fish species distribution (Sect. 14.d.N.4.7.1), aquatic habitats important to fish (Sect. 14.d.N.4.7.2) and the biological characteristics of northern fish populations (Sect. 14.d.N.4.7.3). However, since data on arctic fish species are growing continually the Applicant's data, as presented, may be incomplete.

Pertinent to this description are three major drainage basins, the Mackenzie River basin, the Porcupine River basin and the Beaufort Sea drainage (Sect. 14.d.N.4.7.1); fish species and their spawning dates are listed for these three areas in Table 4.7-1. The Applicant's primary concern, however, is for the species "which are important in sport, subsistence (domestic) and commercial fisheries." These important species are discussed more fully in Section 14.d.N.4.7.1.

The aquatic habitats important to fish populations in the three major drainage basins are discussed in detail in Section 14.d.N.4.7.2; winter use of these habitats is stressed because of the proposed winter scheduling of construction. In the Mackenzie River drainage basin the main channel, major tributaries such as the Peel, Great Bear and Liard Rivers, spring-fed drainages, and lake drainages all offer varied and important aquatic habitat utilized by different species and populations. The freshwater habitats important in the Beaufort Sea drainage are streams with groundwater sources, streams without groundwater sources, and lakes.

The biological characteristics of northern fish populations are discussed in Sect. 14.d.N.4.7.3. The Applicant recognizes the paucity of data, especially with respect to primary productivity, on aquatic environments in areas to be traversed by the proposed pipeline. He concludes that northern fish populations, in comparison with populations in more temperate areas, tend to have slower growth rates, lower annual mortality, greater age at maturity and greater longevity.

The impact of the proposed pipeline on the aquatic environments within the vicinity of the proposed pipeline is discussed in detail in Sect. 14.d.N.7. Situations where the construction of the pipeline might have an effect on fish populations have been identified; this is most likely to occur in "critical areas" such as spawning, rearing, and overwintering areas. In order to minimize such effects, the Applicant proposes to avoid critical areas where possible. Major potential sources of disturbance cited by the Applicant and discussed in some detail are siltation (Sect. 14.d.N.7.7.1), lowered dissolved oxygen levels (Sect. 14.d.N.7.7.2), pollution from toxic substances and natural gas (Sect. 14.d.N.7.7.3), elevated water temperatures (Sect. 14.d.N.7.7.4), water abstraction (Sect. 14.d.N.7.7.5), obstructions to fish passage (Sect. 14.d.N.7.7.6), sub-surface drainage (Sect. 14.d.N.7.7.7) and human access (Sect. 14.d.N.7.7.8).

Relevant Data

The Applicant does not seem to have made use of the available commentaries on Arctic aquatic ecosystems and their strengths and weaknesses. Discussions have been presented, for example, by Johnson (1970), Kalff (1970), the Arctic Institute (1972), Dunbar (1972) and Sprague (1972). Lack of knowledge of these systems is generally accepted and caution recommended in the absence of additional information from short-term and more especially long-term studies. The special conditions that prevail under winter ice in lakes and streams have been studied by

Kalff (1970) and Brunskill *et al.* (1973) respectively. The latter study carried out under the auspices of the Environmental-Social Program, Northern Pipelines, also presents data collected in the vicinity of the proposed pipeline route on the effects of silt and oil on benthic organisms. The assumed benefits of eutrophication in nutrient-poor Arctic waters is open to question (Johnson, 1970; Bliss and Peterson, 1973). Recent work has indicated however that phosphorus control is the key (Schindler *et al.*, 1974) and that judicious use of nutrients might be advantageous if controlled experiments are first conducted to identify problems that may arise.

Recent data on fish distribution and movements have become available through reports by Steigenberger *et al.* (1973), Stein *et al.* (1973) and Jessop *et al.* (1974). New data on spawning, nursery and feeding areas and time of migration and spawning are presented in these reports by the Environmental-Social Program, Northern Pipelines. Bliss and Peterson (1973) include gravel removal from streams and blasting in their list of impacting variables on fish populations but the Applicant has not addressed these questions in his statement. Both Sprague (1972) and Bliss and Peterson (1973) suggest that the accidental large fuel spill might be the most serious hazard faced by Arctic aquatic ecosystems. The data presented by Brunskill *et al.* support this, in that even small quantities of oil spilled into a stream or lake can last for a prolonged period, and have catastrophic effects on benthic organisms.

The question of human access and increased exploitation of Arctic fish resources as a consequence of development is viewed as a major potential problem by many experts including Johnson (1970), the Arctic Institute (1972) Sprague (1972), Bliss and Peterson (1973), Stein *et al.* (1973) and Jessop *et al.* (1974).

<u>Concerns</u>

1. In his proposals the Applicant has concentrated on fish rather than on northern aquatic ecosystems as complete units. Background data on primary and secondary productivity have largely been ignored. Moreover the information available to the Applicant on fish species distribution, spawning, feeding and overwintering and migration routes was incomplete. Additional information has become available since the Application was prepared (Stein *et al.* 1973; Steigenberger *et al.*, 1973; and Jessop *et al.* 1974) but there remain significant knowledge gaps.

(i) The Applicant does not make allowance for variation in fish species' resilience; Stein *et al.* (1973) indicate that the ability to withstand environmental disturbance will vary with species, size, stability of suitable habitat. Arctic char, Arctic grayling, least cisco, Arctic cisco and inconnu are very sensitive to habitat disturbance, the whitefishes moderately sensitive, and northern pike, yellow walleye, burbot, longnose sucker and forage fish species less sensitive. Special precautions should be taken, therefore, when crossing streams inhabited by the more sensitive fish species, especially when such fish are utilised in domestic fisheries.

(ii) The Applicant's approach to the environmental protection of fish resources of first identifying "critical" areas and then avoiding them or formulating special procedures to protect them is appropriate. The Assessment Group is concerned however that not all such critical areas may have been identified, either through lack of data or from too narrow a definition of "critical". An example of the former can be found on the Alignment Sheet for the Ochre River crossing (Sheet IB-0200-1035) which states that this river freezes to the bottom in winter. Yet a 1974 government survey crew found open water, high oxygen levels and the presence of Arctic

grayling in February (Stein, 1974, Pers. Comm.). One cannot yet fully define the term critical with respect to northern aquatic ecosystems except in a few instances such as fish spawning areas and migration routes. In view of these information gaps, the Assessment Group considers that wide safety margins will be needed to protect aquatic ecosystems and fish resources. These safety margins could be narrowed as the level of knowledge increases.

(iii) The sensitivity of aquatic ecosystems is related to size and the physical and chemical characteristics of a particular water body or system, as well as the time of year. Lakes and streams with small watersheds (less than 5000 km^2) are likely to be affected by terrain disturbance to a greater degree than larger watershed and may undergo irreversible changes (Brunskill *et al.*, 1973).

(iv) Northern aquatic ecosystems present particular sensitivities in winter. Such winter conditions have not been fully explored by the Applicant nor has he identified potential problems from construction activities at that time. Large bodies of water under ice, not subject to oxygen depletion (e.g. Mackenzie Delta channels), contain benthic organism populations that are as abundant and diverse as in the autumn. Overwintering fish frequent such areas which may or may not be sensitive to disturbances. However, in streams where sub-ice conditions are less favourable (i.e. low velocity and discharge, low dissolved oxygen levels*) even small disturbances such as the introduction of small quantities of soil organic material could impose severe stresses on overwintering invertebrate and/or fish populations or on eggs incubating in the gravel.

2. The Applicant has used comparisons of predicted increases in suspended sediment with natural "silt flows" (Applicant's words). In the opinion of the Assessment Group such comparisons *per se* do not provide an effective basis for estimating effects of pipeline-related disturbance. Time of year is critical. For instance, in their natural cycles many eastern tributaries of the Mackenzie have high suspended sediment loads at peak discharge but after a relatively short period, they flow clear. Invertebrate life cycles are synchronized to this normal cycle and although an increase in suspended sediment in spring would have little or no harmful effects, it almost certainly would during say July or August (Snow, 1974 pers. comm.). Concerns with respect to suspended sediments are discussed more fully in topic "Suspended Sediments".

3. As discussed in topic "Waste and Toxic Materials" the Applicant will be using a variety of organic chemical compounds which are toxic to components of aquatic ecosystems. Special attention is focussed here on fuels and methanol (pipeline testing) in view of the large volumes being in one place at one time, on the sensitivity of benthic organisms to such compounds, and the critical nature of open water areas in winter where fish are concentrated.

4. The construction and operation of the pipeline may also interrupt groundwater flows in the porous alluvium of river channels. Overwintering populations of fish and incubating eggs in open water areas dependent on such flows would be harmed by such interruptions. This concern has been dealt with more fully in topic "Springs and Icings", and "Requests for Supplementary Information" (#45)

5. Large quantities of water will be required by the Applicant for sundry purposes. No problems

*Oxygen level can fall below 50% saturation.

are foreseen during the open water season providing that intakes and ditches are adequately screened to prevent the mortality of fry, but, serious concerns could arise in winter in certain locations in the Mackenzie Valley and along the Yukon North Slope. Extraction of any substantial quantity of water from areas of critically low discharge could adversely affect overwintering fish populations. Examples of such areas are as follows:

(i) *Vermilion Creek* It is doubtful that water requirements of compressor station and camp could be met without adversely affecting overwintering grayling populations.

(ii) *Oscar Creek* This stream is utilized by overwintering populations of pike, burbot and ninespine sticklebacks, whose well-being could be jeopardized if water is removed for the proposed compressor station and camp.

(iii) *River Between Two Mountains* As overwintering populations of burbot, slimy sculpins and spottail shiner utilize this stream, insufficient water may be available for compressor station and camp.

(iv) *Rat River* This river is utilized by Arctic char which overwinter in the headwaters. During their upstream migration in August and September the river is low and further flow reduction at that time might hinder their passage. The proposed compressor station and camp is also located 0.1 miles from a fishing camp used by Fort McPherson residents during the fall migration.

(v) *Malcolm River, Firth River and Fish Creek (Yukon).* The open water areas close to the pipeline route are few and far between. All may be utilised by overwintering fish populations. Extraction from any such source to satisfy pipeline requirements on the Yukon North Slope may, therefore, endanger fish populations.

6. An accidental release of large volumes of warm untreated pipeline test water during winter into an open water area could have harmful effects; mortality could occur within overwintering populations of fish or there may be undesirable effects on incubating eggs. This concern has been dealt with more fully in topic "Pipe Testing".

7. The inter-relationships of the flora and fauna of northern aquatic ecosystems have in part evolved in response to low nutrient levels. There is a concern that the introduction of nutrients to such a system could alter these inter-relationships and be harmful. The accummulation of oxygen-demanding sustances under winter ice, for example, could reduce dissolved oxygen levels below those required by overwintering fish populations. Even if this were not the case, a sudden algal bloom in spring due to this nutrient bank might not be assimilated by the ecosystem. These dangers would not arise if factors favouring eutrophication—which are thought to be primarily the addition of phosphorus and possibly nitrogen—could be avoided. This necessitates not adding untreated sewage to lakes and streams and taking special care not to apply fertilizers in such a way that they might also enter waterbodies (*see* topic: "Waste and Toxic Materials").

8. Fish are sensitive to disruption during migration, spawning and egg incubation periods, and severe stress could result from blockages on rivers and streams or sedimentation of spawning beds during these periods. It is important that construction activities be timed to avoid these sensitive periods. Critical periods are September 1 to November 15 for all spawning species and May 1 to June 30 for spring spawning species, but each

stream must be examined individually for specific times of fish activities. The general break-up pattern of the Mackenzie River system is such that spring spawning activities can be expected to begin and end approximately two weeks earlier in southern reaches of the system than in the north. Conversely, the fall spawning cycle in the north is generally about two weeks ahead of that to the south.

9. Sensitive areas occur on many rivers along the proposed pipeline route. For adequate protection of fish, it is important to avoid such areas if possible and, if they cannot be avoided, to modify pipeline and related activities to minimize disturbance. The main areas with importance to domestic fisheries are as listed below:

(i) *Mackenzie Delta*

- The estuary is very sensitive to spills of fuels and other toxic fluids as effects are maximized by the shallow and exposed areas having little tidal action to aid flushing.
- The delta is extremely productive and utilized by several species for a nursery and feeding area. Migratory fish populations, including Arctic char, broad whitefish, humpback whitefish, Arctic cisco, least cisco and inconnu, must negotiate the delta on upstream and downstream migrations.
- Horseshoe Bend on the Middle Channel is a spawning area for humpback whitefish.
- Lakes which are connected to delta channels or the sea are extensively utilized by fish.
- Streams connecting delta lakes to channels are important during September when resident whitefish, cisco, burbot and northern pike migrate from lakes which are unsuitable for overwintering.
- Whitefish on the upstream migration from the coast move through the East, Middle and Peel Channels.
- A substantial domestic fishery and an experimental commercial fishery presently exist in the delta. These depend on resident and migrating fish populations.
- The channels of the delta are utilised by overwintering fish. Conditions under winter-ice are good (clear and well oxygenated water) and productivity maintained at a moderate level especially while winter light conditions permit algal growth.

(ii) *Big Fish River*

- Contains an Arctic char population of 12,000 to 17,000 fish which are utilized in a fall domestic fishery by Aklavik residents. At least one life history stage of char in stream at all times.
- Reduction in fish number could have biological, social, and economic effect.

(iii) *Rat River*

- Contains spawning grounds of one of two known Arctic char populations in the Mackenzie River system.
- Fished domestically by residents of Aklavik, Arctic Red River, and Fort McPherson.

(iv) *Peel River*

- Large upstream migrations of inconnu, broad whitefish, least cisco, and Arctic cisco in July and August.
- During early October after freeze-up downstream migration of inconnu and cisco occurs.
- A substantial domestic fishery utilizes these stocks. Proposed pipeline route crosses Peel River 5 miles downstream from Fort McPherson in a domestic fishing area.

(v) *Arctic Red River (mouth)*

- The mouth of the river and back eddies of the Mackenzie River in this area appear to be spawning areas for humpback and broad whitefish during October and November.

- Area is fished domestically by residents of Arctic Red River and Fort McPherson.
- Turbidity and silt levels in the Arctic Red and Mackenzie Rivers have declined by October. Additional silt at this time, therefore, could be deleterious to whitefish eggs.

(vi) *Swan Lake - Creek Drainage*

- Contains spawning grounds of a large population of Arctic grayling which is sometimes fished by Arctic Red River residents.

(vii) *Great Bear River*

- Contains summer resident population of Arctic grayling; some Arctic grayling from the Three Day Lake system move to this area during early summer.
- Residents of Fort Norman, Fort Franklin conduct a domestic fishery in this river where it enters the Mackenzie River.
- This river is used for sport fishing, has recreational potential, and has potential for further development.

(viii) *Willowlake River*

- Contains numbers of walleye fry.
- Some domestic fishing at the mouth
- Has sport fishing potential.

(ix) *Jean-Marie Creek*

- Contains spawning grounds of large populations of yellow walleye and Arctic grayling. These species are heavily fished domestically by residents of Jean-Marie village.

(x) *Trout River*

- Supports significant spawning area of Arctic grayling, yellow walleye and whitefish.
- Heavily utilised as a nursery area.
- One of the few systems in the area with sport fishing and recreational potential.

10. The Applicant has indicated (Sect. 14.d.N.7.7.8) that fishing by pipeline personnel will be prohibited during the construction period. The further concerns of the Assessment Group in this regard are recorded in "Requests for Supplementary Information" (#7).

Highlights

The Applicant's proposals relative to protection of fish resources are limited by information gaps and by concentrating principally on fish rather than the ecosystem of which they are a part. The Assessment Group considers that a broader view of the aquatic ecosystem would permit a more effective identification of problem areas, assessment of potential impacts and development of protective measures.

1. Fish species vary in their tolerance to disturbance of their habitat. Therefore special protection measures would be appropriate at pipeline crossings of streams containing sensitive species.

2. Not all areas that are of critical importance for fish and aquatic habitat are known because of incomplete data. Hence, the Assessment Group considers that the use of wide safety margins will be required for adequate protection of aquatic ecosystems and fish resources.

3. Fish and other aquatic organisms are highly sensitive to disturbance under a variety of situations that prevail in winter; hence winter construction *per se* would not avoid negative impacts aquatic ecosystems. Particular concerns in winter relate to siltation, depletion of dissolved oxygen extraction of water and disruption of flow. Crossing locations are listed where removal of water in winter could be of particular concern.

4. Prediction of impact of suspended sediment on the aquatic ecosystem requires an awareness of seasonal variation in sediment loads. Specific

oncerns over siltation are outlined in the topic Suspended Sediment".

. The introduction of other forms of pollutants nto water systems raises a variety of concerns. his paper makes particular reference to:

(i) organic chemicals and other toxic substances (*see* topic "Waste and Toxic Materials").

(ii) large volumes of warm untreated water that could enter lakes and streams as the result of an accidental spill during pipe testing (*see* topic "Pipe Testing").

(iii) sewage effluents and fertilizers (*see* topic "Waste and Toxic Materials").

. Fish are sensitive to disruption during migraion, spawning and egg incubation periods. Disurbance of streams by pipeline activities would e of particular concern during the spawning eriods May 1 to June 30 and September 1 to ovember 15.

. Protection of fish and aquatic ecosystems will e of particular importance in the vicinity of omestic fishing areas. If such areas cannot be voided by the pipeline and pipeline-related ctivities, special measures may be needed to enure adequate protection of the resource. Specic areas of concern in this regard are listed.

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9.7 SUSPENDED SEDIMENT

Introduction

Suspended sediment is a common natural component of many waterbodies, and is a significant factor in the development and characteristics of the aquatic ecosystem. Elements of the aquatic ecosystem are adapted to the natural concentrations and cycles of suspended sediment. However, disturbance of the natural system may produce changes that exceed the tolerance limits of certain organisms; increased mortalities may result.

Increased concentrations of suspended sediment may stem directly from such activities as right-of-way clearing and construction at river crossings, or indirectly from accelerated erosion caused by construction, operation, and maintenance activities. This paper discusses the Applicant's proposal in terms of the risk and possible environmental consequences of increasing the concentration of suspended sediment in nearby waterbodies.

Large amounts of fine sediment introduced into a river may result in some local deposition on the river bed, although much of the sediment would go into suspension and be carried downstream. The concentration of this suspended sediment tends to decrease exponentially downstream. Thus the effect of its introduction decreases in importance downstream. It is necessary, however, to examine the effect of the increased concentrations of sediment near the source in terms of their possible long-term impact on the aquatic ecosystem.

Increase in turbidity associated with high suspended sediment loads reduces light penetration and has an adverse effect on primary productivity, limiting the growth of algae and other aquatic plants. As these plants are at the base of the food pyramid, fish at the top are also affected. Thus reduction in light penetration can have widespread effects. Reduction in primary productivity can limit the number and variety of organisms available to benthic invertebrate populations. Many species are sensitive to siltation and studies have shown that silt may injure the gills of aquatic insects. Because of their sensitivity to silt, higher concentrations of suspended sediment lead to a reduction in the over-all density of invertebrate populations, a replacement of sensitive species by more tolerant species (particularly midge larvae *Chironomidae* and worms *Oligochaeta*), and a reduction in species diversity. Many species eliminated by siltation (caddisflies, stoneflies, and mayflies) are important fish food.

Gills of fish are injured by silt in suspension when concentrations are high and exposure is long. Gill membranes may be damaged and in severe cases death may result. Loss of invertebrate populations or their replacement by less desirable species may lead to the exodus of fish populations.

Introduction of silt into intragravel spaces on the bottom of a waterbody can reduce intergranular flows and oxygen to levels low enough to cause migration or death of benthic invertebrates. These may, however, be replaced by more tolerant species such as midge larvae and worms.

The more serious effects of sedimentation manifest themselves during the egg-to-fry stages in the life history of fish. Consequently, damage is most likely to occur where there is deposition of silt near spawning grounds or rearing areas used by fish fry after emergence. Sediment can cause mortality to eggs and alevins in spawning gravels by filling the interstices in the gravel and reducing intragravel flow, thereby reducing the supply of oxygenated water to the egg and interfering with the removal of waste products

(carbon dioxide and ammonia). Eggs deposited on the surface may be smothered. The silt may also "cement" gravels, blocking fry emergence and eliminating the spaces between stones so important to the survival of fry that use such areas to escape predation.

The effects will vary with the time of year. Such adverse effects on eggs and fry render fall spawners, such as Arctic char and whitefish, particularly sensitive in late fall and winter, whereas spring spawners, including Arctic grayling and northern pike are particularly sensitive in spring and early summer.

The ability of the ecosystem to survive increased concentrations of suspended sediment is a function of the timing of the increase (time of year, as well as sustained *vs.* temporary) with respect to the life cycle of the organism, levels of increase, tolerance limits of the aquatic organisms, and importance of the various organisms to the continued health of the ecosystem.

Stream habitats differ in their capacity to recover from effects of sedimentation. If disturbance is of short duration and limited magnitude, disturbed areas may be subsequently reinvaded by invertebrates and fish. The recovery may be most rapid when only short sections of the stream are affected, providing that there are adequate reservoirs of new organisms upstream to recolonize the area and where the degree of damage is small. Under these circumstances recovery may be rapid after the silt introduction has stopped.

Applicant's and Other Data

The Applicant recognizes that pipeline-related activities will result in the introduction of suspended sediment into nearby water bodies. Principal sources of this sediment are at river crossings, the pipeline right-of-way, winter and access roads, borrow sources, and burned areas (Sect. 14.d.N.7.7.1). The Applicant has proposed a series of erosion-control measures that are intended to minimize entrainment of fine sediment and its delivery to nearby waterbodies (Sect. 8.b.1.3.8.4.1).

River crossings would be of two types, major and minor, depending upon whether there is significant flow in winter, in which case construction is best carried out in summer, or whether winter flow in the channel is absent or nearly so, in which case construction would proceed in the winter (*see* topic "River Crossings"). Wherever flow is encountered at river crossings, spoil from the trench would be cast downstream (Sect. 13.a.6.5.11). Open water beneath winter ice was encountered by the Applicant at more than half the minor streams examined in the spring of 1973 (Sect. 14.d.N. 7.7.1). At those crossings, frozen to the bottom in winter, the Applicant has noted that entrainment of suspended sediment would be confined to material scoured from the backfill the following spring. (It should be noted here that winter ice conditions are known to be variable from year to year at any given site; a location that is frozen to the bottom one year may not be the next, and *vice versa*).

Data presented by Brunskill *et al.*(1973) on the effects of silt in streams and lakes within the Mackenzie system (NWT) and the northern Yukon are particularly relevant. Their findings indicate that physical, chemical, and biological characteristics of waterbodies west of the Mackenzie River, in the Mackenzie Delta, and on the Yukon North Slope show distinct differences and that responses to silt introduction and recovery rates differ likewise. This work is particularly useful in that it deals with Arctic ecosystems. Such data are scarce but probably more meaningful than those that are collected in southern regions and applied to northern situations.

It is apparent from both the Applicant's and other data that, although there is some information available on the physiological effects of suspended sediment on fish, there is a marked paucity of specific data for fish and other types of Arctic aquatic fauna and flora. Silt tolerances of species may vary from watershed to watershed, from population to population. Detailed information is not available at this time.

Concerns

1. The Applicant has noted, and the Assessment Group agrees, that local concentrations of suspended sediment will be increased, at least temporarily. Of considerable concern to the Assessment Group is the shortage of definitive statements on location, timing, and amounts of anticipated increases of suspended sediment, and of data leading to an understanding of tolerance limits of aquatic organisms under Arctic conditions, the importance of these organisms for the health of the aquatic ecosystem, and recovery times for affected waterbodies. It is known that different organisms differ widely in their ability to survive increased sediment concentrations. Tolerance probably varies as well from season to season for a particular species.

2. The Assessment Group is concerned also over the general shortage of inventory data regarding fish habitats and the physical, chemical, and biological characteristics of Arctic waterbodies. For example, although the Applicant maintains that the proposed Taglu branch of the pipeline route avoids critical fish habitat, no specific studies are cited for this section. Preliminary governmental data have indicated that many of the lakes of the Mackenzie Delta are extremely productive and probably highly sensitive to disturbance.

3. In view of the shortage of definitive criteria regarding the severity of the impact of increased suspended sediment concentrations on aquatic organisms, the Applicant has recognized the need to minimize the introduction of fine sediment into waterbodies. A request for more details on specific techniques proposed to control this is included in the "Requests for Supplementary Information", #42. For example, stabilization of the right-of-way by revegetation may take a few years. Erosion along the right-of-way, particularly during the spring run-off, could introduce large quantities of fine sediment into nearby waterbodies. A buffer zone of undisturbed vegetation between the pipeline and waterbodies (excluding, of course, essential pipeline crossing points) that would reduce the likelihood of sediment being introduced into natural waterbodies would offer some protection against this risk. Aspects such as construction at river crossings, borrow-pit operations, and construction of pads and roads have high potential for introduction of fine sediment into the water during the following spring.

4. Water flowing beneath river ice, even in the case of the usually turbid Mackenzie River, tends to be clear with a very low concentration of suspended sediment. There is evidence from the East Channel of the Mackenzie that algal blooms occur beneath ice, benthic populations are at least as high as in summer, and fish overwinter in the area. Overwintering fish populations, incubating eggs in the gravel, and benthic communities are particularly susceptible to siltation during low-flow conditions in winter.

5. Some specific locations where fish populations may be endangered by increased concentrations of suspended sediment resulting from proposed activities, are cited below:

Mackenzie River (Point Separation). This area is used for domestic fishing during summer and fall. There is a camp one and a half miles up-

stream of the crossing site. Approach preparation, trench excavation and pipe installation are scheduled for the period July to October. Humpback and broad whitefish migrate past this point between September 1 and November 15 to spawning areas in the Mackenzie River near Arctic Red River. Also, since suspended sediment levels in the Mackenzie River have declined by the spawning period, siltation from construction activities might result in egg mortality downstream. Consideration could be given to completing the construction before September or carrying it out later, during the winter.

Peel River (M.P. 432). The river crossing and wharf are located in a domestic fishing area and are subject to the same concerns outlined above.

Great Bear River (M.P. 421). There is concern that the approach preparation, trench excavation and pipe installation (including the construction of a berm one-third of the way across the river) will lead to erosion of the steep banks and subsequent sediment introduction. Fish populations use this clear river as a spawning and feeding area and as a migration route. The potential for adverse effects on fish could be reduced by rescheduling the construction to the winter months, relocating the crossing, or employing special techniques to minimize the potential for increased suspended sediment concentration.

Highlights

1. Locally increased concentrations of suspended sediment will result, at least temporarily, from pipeline-related activities. Such increased turbidity could diminish primary productivities, and the sediment in suspension could adversely affect benthic and fish populations. Deposition of fine sediment in spawning grounds could clog gravels and lead to egg mortality.

2. The shortage of information regarding tolerance limits of particular aquatic organisms, the specific importance of these organisms to the local ecosystem, and the recovery rate of the aquatic ecosystem in a waterbody that has been temporarily subjected to an unnatural increase in suspended sediment, make it difficult to assess the long-term significance of expected increases in suspended sediment concentrations. This uncertainty is coupled with the general paucity of data on the characteristics of waterbodies and their aquatic populations.

3. Winter conditions are particularly sensitive to increases in suspended sediment because of the importance of a limited number of available overwintering areas for fish, the natural clarity of the winter flow, and the demonstrated high levels of biological productivity in ice-covered waterbodies.

4. Protection of fish and other aquatic organisms from sediment problems could be facilitated by development of standards for scheduling, construction methods, and maintenance repair methods designed to limit introduction of fine sediment into waterbodies, and by review of the Applicant's detailed plans relative to these standards at the final design stage.

5. At locations where risk to important fish resources is appreciable, such risk could be reduced by rescheduling, relocating construction, or employing special techniques to minimize increase in suspended sediment concentration.

Literature Source

Brunskill, G.J. *et al.*, 1973. "Ecological Studies of Aquatic Systems in the Mackenzie-Porcupine Drainages in Relation to Proposed Pipeline and Highway Developments", Prepared for the Task Force on Northern Oil Development, Ottawa, Repts. 73-40 and 73-41.

9.8 WASTE AND TOXIC MATERIALS

Introduction

Wherever towns and cities flourish, wherever industry prospers and modern agriculture thrives, it has been the widespread experience that natural waterbodies become contaminated with harmful or offensive wastes (Anon., 1972). These vary in nature from perhaps the oldest pollutant generated by man—sewage—through those arising from the more traditional industries, to new products such as detergents, fertilizers, oils and other organics that daily become more and more part of modern man's way of life.

Unfortunately, when indiscriminately released onto land or water surfaces, such substances can very adversely affect the quality of the physical and biological characteristics of an environment. Fish may be killed, animals and birds driven away, water rendered unpotable, and shorelines ruined. In addition to the direct costs of such losses, there are indirect ones required to accomplish the difficult task of cleaning up a damaged environment. Increasingly, therefore, industry and government have designed procedures and regulations to control harmful effluents and to ensure spillage does not occur when potentially harmful substances are transferred from one container or place to another.

In spite of such precautions, accidents happen. From 1 January 1973 to 30 June 1974, for example, 34 oil spills were reported for north of 60°N. and altogether some 262,000 Imperial gallons of oil (equivalent to that held in 52 tanker trucks) were lost. Over 90 per cent of this loss was diesel or stove oil and individual spills varied from as much as 49,000 gallons down to 70 gallons (Environmental Emergency Branch, Environmental Protection Service, Environment Canada).

The question examined below is whether the Applicant's proposed procedures appear able to reduce such accidental pollution. Pipeline development involves the handling, transportation, use and disposal of a variety of potentially harmful organic and inorganic substances. As regards fuels and lubricants alone, for example, over 65 million Imperial gallons (equivalent to the quantity held in 13,300 tanker trucks) will be used during the construction phase, with possible individual spills ranging in amount from 175,000 gallons (the content of one storage tank), through 5,000 gallons (one tanker truck), to quite small losses. When other substances to be used are taken into account three broad groups may be identified. In decreasing order of potential concern, they are: (i) lubricants and fuels; (ii) paints and other specific-use chemicals; (iii) sewage, garbage, etc.

"Requests for Supplementary Information" (#53) have been prepared in regard to certain aspects of these waste and toxic materials; in this paper, their possible impacts on components of the environment have been examined without the benefit of such supplementary information. Eight areas of concern arise, the more important centring on oils and lubricants, contingency plans and various wastes. Much detail is provided in the main text below on various ways by which environmental harm might be avoided, and these warrant consideration by the time final design is being formulated.

Applicant's and Other Data

Some Basic Properties of Substances

It may assist to outline certain of the basic characteristics of the substances falling within the three broad categories listed above. The first

category—lubricants and fuels—includes turbo fuel, heating oil, diesel oil and gasoline. These liquids have most potential for harmful impact upon ecosystems and, because they are to be used throughout both the construction and operation phases of pipeline development, they must be viewed as having a potential for harm over a very extended time scale. Lubricants and fuels are extremely toxic to aquatic organisms and their potential for harm is prolonged during winter through their depressed volatility at low temperatures. Turbine lubricants—including the so-called triaryl phosphates—are especially toxic; hence even small concentrations are dangerous.

The second group includes paints, corrosion-prevention coatings, flushing and cleaning agents, pipe-testing fluids and fertilizers. Such substances have a high potential for impact upon ecosystems, but their use appears restricted to the later stages of the construction phase. Flushing and cleaning agents and pipe-testing fluids are used in much larger amounts than paints and corrosion-inhibitors and would present a serious hazard if released into natural waterbodies. Fertilizers may pose a problem to aquatic ecosystems if they are released directly into waterbodies.

The third category includes sewage effluents (treated), solid wastes, garbage and natural-gas leaks (from pipe breaks). Of the three main groups of substances, this one has the least potential for impact. However, the substances are able to exercise their effects over a time scale that includes both the construction and operational phases. Sewage and solid wastes from construction camps are expected to be substantial.

Applicant's Proposals

Large quantities of the first group—lubricants and fuels—will be used during the pre-construction and construction phases of pipeline development, and moderate quantities during operation. The total amount indicated by the Applicant is 375,000 tons or over 65 million Imperial gallons (Sect. 13.a.5.4). North of Hay River fuel will be barged to storage sites along the Mackenzie River or Beaufort Sea. Where practical, fuel will be pumped directly from the barge into storage tanks. When transportation is required, fuel will be loaded into tank trucks and driven to the storage site. A limited amount of fuel may be brought in via the Mackenzie Highway (Sect. 13.a.6.4.8).

When fuel is to be stored, bladder tanks of up to 1,500-barrel (52,500 Imperial gallons) capacity and/or steel tanks of up to 5,000-barrel (175,000 gallons) capacity will be used. Tanks will be located in a separate area and surrounded by impermeable dykes. Tankers, wheel- or track-mounted, will transport fuel directly either to construction equipment or to tank-storage facilities. The procedures will include special precautions to ensure that hydrocarbons are not introduced into natural waterbodies (Sect. 14.d.N.7.7.2).

The paints and corrosion-preventive coating substances in the second main group are to receive special care when transported, stored or disposed of (Sect. 14.d.N.2.2.5). Two pipe-testing fluids will be used, warm water or a water-methanol mixture. Water will "...normally be disposed of... directly into watercourses or onto ice over watercourses." (Sect. 13.a.7, p.61). However, if such water is low in oxygen, it will be re-oxygenated by spraying and if too warm, cooled before discharge (Sects. 14.d.N.7.7.2; 14.d.N.7.7.4). Precautions will be taken to prevent the loss of test fluid, but if a spill occurs the fluid will be allowed to disperse via the natural drainage. The water-methanol mixture will be allowed to pond, then pumped into bladder-type storage tanks (Sect. 13.a.7). The mixture will be re-used or,

after dilution or fractional distillation, disposed of as one per cent (v/v) methanol in water. The methanol distillate will be burnt or used for secondary purposes.

Inorganic fertilizers will be used to assist revegetating the right-of-way. A large proportion of the fertilizers, including those supplying nitrogen, phosphorus and potassium, will be "... incorporated by plants and microorganisms, bound in the soil or otherwise removed from circulation." Little is expected to enter natural waterbodies, and that which does "may...be beneficial." (Sect.14.d.N.7.7.2).

For the third category, the Applicant's proposal is that camp waste-water will "generally" receive secondary treatment before discharge into the environment (Sect. 8.b.1.4.6), treatment being by sewage lagoon or package treatment-unit. In the lagoon system, wastes will be retained for about one year before discharge, but in the treatment-unit system the waste will be aerated for 20 to 24 hours then discharged into the environment via a settling tank. Sludge produced from the treatment-unit will be incinerated. Wherever possible, the discharges from lagoons and package treatment-units will not directly enter waterbodies, but will be routed through muskeg or other carefully selected areas to minimize environmental damage. Permanent facilities (compressor stations) will have treatment units or incinerating toilets (communication-repeater stations). Non-combustible wastes will be buried at approved sites and flammable materials incinerated to avoid attracting birds and bears.

Natural gas could be released during the operational phase through a pipe break (*see* topic "Environmental Safety of Pipeline"). For a pipe break under water, the gas—composed of over 90 per cent methane—would bubble rapidly to the surface and escape, except when a layer of surface ice is present. In these circumstances reduced partial pressures of oxygen in the water may occur which, combined with the entrapped methane, could give rise to toxic conditions (Sect. 14.d. N.7.7.3). Pipe breaks are, however, expected to be very uncommon.

Relevant Legislation and Guides

For the handling and disposal of waste and toxic materials the Applicant can avail himself of a range of relevant legislation and guides. These include certain Acts—the Arctic Waters Pollution Prevention Act, the Northern Inland Waters Act, the Fisheries Act, the Canada Water Act, the Canada Shipping Act and the Territorial Lands Act. There are also various ordinances of the Territorial Governments and Government Guidelines. For the management of wastes in the Arctic, specific guidelines have been developed (Grainge *et al.*, 1973), and the use of oil dispersants for containing and cleaning up spills is similarly documented (Ruel *et al.*, 1973).

Brunskill and his co-workers (1973) have studied the more fundamental aspects of the effects of oil on aquatic ecosystems and as a result of such studies have formulated recommendations for oil containment and clean up. Of particular interest to the Applicant will be these researchers' views on the ineffectiveness of floating booms to contain oil spills in running water. Of specific relevance will be the contingency plans for dealing with oil spills developed for the Northwest Territories (by the Government of the Northwest Territories) and for the Yukon (by the Environmental Protection Service of Environment Canada).

The special problem of bears being attracted by garbage has been studied by Pearson (1974), who recommends the daily incineration of camp wastes to remove the source of attraction. There is,

n addition, much unpublished information and expertise available in Environment Canada in the ields of liquid- and solid-waste management and n contingency planning. This, along with experise from other government agencies could be made vailable to ensure the best technology is applied y the final design stage.

Concerns

ight main concerns have been identified. These entre on fuel (oil) spills, lubricants, contingency plans, pipe-testing liquids, natural-gas eaks, fertilizers, sewage, solid wastes and on articularly sensitive aquatic environments.

uel (Oil) Spills

his is the major concern for, as noted above, ver 65 million Imperial gallons will be handled nd used during the construction phase of the ipeline. Spills may occur during transportation, ransfer and storage through accidents, inadequate andling or other causes. Typical situations here spills could occur and the scale of the ossible spill involved are as follows:

(i) barge damaged on trip from Hay River; oil tank ruptured (400,000 Imperial gallons);

(ii) hoses break or leak during transfer of fuel from barge to main storage tanks on shore (4,000 down to 4 gallons);

(iii) storage tank ruptures at staging area or at main stockpile site (up to 170,000 gallons);

(iv) hoses break or leak during transfer of fuel from main storage tank to tanker truck (4,000 down to 4 gallons);

(v) tanker truck damaged in road accident; tanks ruptured or valves leak (5,000 down to 5 gallons);

(vi) hoses break or leak during transfer of fuel from tanker truck to field storage tanks or bladders (up to 80 gallons);

(vii) field storage tanks or bladders ruptured by machinery or wildlife (up to 50,000 gallons).

Moreover, many of these transfer operations will be repeated several hundred times in one season. A five-ton tanker truck, for example, will make from 440 to 540 trips during one construction period on the Yukon North Slope (Environment Protection Board, 1973). The opportunities for spills are extremely numerous, therefore, and range from the sudden surges arising from a ruptured storage or transportation tank, to the steady trickle from a faulty hose, pipe or valve.

Concern centres especially on the refined oils—gasoline, diesel and light fuel—for they are the most toxic and constitute the bulk of all fuels used during construction. Whereas in temperate latitudes such oils lose their more volatile fractions quickly, in the colder northern and Arctic climates they are retained, and the toxic condition is prolonged.

The Applicant has recognized these dangers and intends to adhere to the relevant federal and territorial regulations. Nevertheless, there are a number of special precautions that could be taken to reduce the chances of spills. These warrant careful consideration. Thus, for fuel storage, steel tanks with surrounding dykes are less vulnerable to rupture than bladders. The regular inspection of hoses and valves can reveal

wear or damage before a failure leads to environmental damage. Contingency plans are sounder if they stress prevention as well as cure, and are more effective if structured into prevention, containment and clean-up procedures. They are best developed in consultation with federal (e.g. DIAND, MOT, DND and DOE) and territorial governments to cater for specific fuels and circumstances. This would involve taking into account the special problems of oil spills under or over ice or snow and the deployment of equipment to ensure the fastest response to spills in particularly sensitive areas. For the special case of the Mackenzie Delta many of the data being generated under the collaborative industry-government Beaufort Sea program should prove useful, especially in relation to the behaviour of oil in ice. There appears a need, too, to develop a technique to detect oil under ice or snow and to be able to track its movement at any time of day in any weather. Finally, the conventional methods of containment utilizing booms may need to be modified for running water, especially during times of peak flow.

Lubricants

The high-temperature turbine lubricants, including the so-called tri-aryl phosphate compounds, are extremely toxic to aquatic and other organisms, even in very small amounts. Such lubricants are presumably transported and stored in small containers. The chances of damage could be minimized if the handling, storing and disposal procedures take account of the compounds' acute toxicity. Adequate dyking around stockpile sites would prevent the contamination of natural drainage waters.

Pipe-Testing Liquids

The environmental concerns centred on the use of warm water and water-methanol mixtures for pressure testing the pipeline system have been comprehensively explored elsewhere in this Report (*see* topic "Pipe Testing"), hence only summarized remarks and a few special additional points are made here. Some 25,000 tons or 6.3 million Imperial gallons of methanol will be used altogether during the construction phase, mostly as a 74:26 (v/v) water:methanol mixture and in amounts necessary to fill not more than a 10-mile length of the pipe. Such a segment of pipe contains 3.9 million gallons. Proposed disposal arrangements envisage reducing the methanol content of the spent liquor to one per cent, then discharing this solution onto land, water or ice surfaces. If the pipe breaks under test the escaping water-methanol mixture will be allowed to pond, then pumped into bladder tanks for eventual removal and processing. There are five main concerns. The first centres on the general handling arrangements for the large overall amount of methanol. Methanol is highly toxic to aquatic organisms and spills could be very damaging. The second concern arises from the proposal to discharge the one-per-cent or diluted water-methanol mixture into waterbodies. Over 100 million gallons of one-per-cent mixture would have to be discharged and there is considerable doubt as to the harmlessness to aquatic organisms, especially spawning fish and eggs, of such a mixture (McMahon and Cartier, 1974). As explained fully elswhere, this concern could be avoided if the mixture were distilled and the aqueous residue discharged into an especially selected area, where the toxic ingredients could be absorbed by the soil and prevented from percolating into drainage waters. A third concern arises from the possible loss of large volumes of warmed water or water-methanol mixtures in the event of a pipe break during testing. The problem is, unfortunately, inherent in pipe-testing, but the effects might be less damaging in highly sensitive environments if less than 10 miles of pipeline system were tested and if water rather than water-methanol

were used. A fourth concern stems from the possible disposal of large volumes of warmed water into waterbodies of small flow, whereby appreciable disturbance to fish habitat could occur. And the final concern, which has been touched on under "Oil Spills" above is that there may be no contingency plan available especially tailored to defusing the special dangers of methanol or water-methanol mixtures.

Natural-Gas Leaks

The release of natural gas from the pipeline system, through normal venting at compressor stations and through breaks in the pipeline, has been discussed in detail elsewhere in this Report (*see* topic "Environmental Safety of Pipeline"; "Air Quality, with Particular Reference to Compressor Operation"). Essentially, no danger to fauna was seen from normal venting, but the better quantification of data would assist. For pipeline breaks, quite large volumes of gas could be released, which, for a break on land could entail a considerable risk of fire or explosion. The gas itself, however, and its ability to diffuse rapidly upwards, combine to pose little, if any, danger to people or animals, unless exceptional weather and topographic conditions prevail. Although breaks may occur at any point along the pipeline, it has to be stressed they happen very infrequently. For pipe breaks under water, it is possible their implications for aquatic flora and fauna have been under-emphasized by reference to old data. In open-water situations, most of the gas would bubble to the surface and escape. Methane is very slightly soluble in water at ambient temperatures (about 10 cm^3 in 100 cm^3 of water), and it is possible that some harm could be done to fish which are spawning, undergoing spawning migration, or overwintering in clear water areas. The situation could be more severe for a break under ice, for the methane may lower dissolved-oxygen concentrations in the water. No easy or direct solution to this perhaps rarely occurring problem suggests itself, but toxicological data in respect of the relevant fish species north of 60^{o}N. would permit a more realistic appraisal of the danger.

Fertilizers

The raising of the nitrogen and phosphorus contents of waterbodies through run-off and drainage from heavily fertilized surrounding land has been a major factor leading to the eutrophication of some waterbodies. There is concern that the fertilizers used for assisting in the revegetation of the right-of-way might exercise a similar effect. Experience in forest and wilderness areas elsewhere and a consideration of the proportion of land area being fertilized, in this instance in relation to the area of waterbodies, suggest there will be no danger to waterbodies provided that fertilizers are not spread on snow or on the waterbodies themselves. As there is considerable difficulty in applying the intended dosages of fertilizers by aerial application and in sharply delineating the commencement and shut-off of the fertilization of areas, the prospect of accidentally spreading fertilizers directly on to waterbodies is not as unlikely as might be thought (*see* topic "Revegetation").

Sewage

For package treatment-units, concern arises from the location of the effluent outfalls, as effluent with even a low B.O.D. (Biochemical Oxygen Demand) could bring about a lowering of dissolved-oxygen concentrations that would be of critical significance in overwintering fish habitats. Clearly, appropriate location of the effluent outfalls should avoid such potential dangers. Sewage lagoons for waste treatment are also proposed, where

the sewage would be retained for twelve months before discharge. The concern in this case is that lagoons are sound in design, that they are not subject to flooding and can accommodate expected volumes without releasing raw sewage into nearby natural waterbodies. Particular concerns over flooding pertain to low-lying sites along the Mackenzie River and on the Mackenzie Delta.

Concern arises also on the treatment of sewage lagoons after their need has passed. Adequate site-rehabilitation proposals should cater for this concern.

Solid Wastes

Concerns over disposal of solid wastes involve mainly domestic waste from camps and waste construction material. Daily burning of domestic waste coupled with burial of non-combustible material would help to avoid attracting bears and other wildlife. Regarding waste construction materials, the Applicant proposes (Sect. 13.b.6.7) to burn or bury them at designated locations and particularly in abandoned borrow pits. It is expected that specific provisions regarding such waste disposal will be included in the terms attached to relevant land-use permits.

Sensitive Aquatic Environments

All aquatic organisms and habitats are affected by spills of toxic compounds. There are, however, degrees of importance that are determined very much by location. In other words, spills in some locations would cause much more harm, because the locations are generally highly productive or are productive of particularly valuable species. Such vulnerable or critical locations are the Mackenzie Delta, the confluences of minor and major tributaries, back eddies and side channels. The upper reaches of streams are critical, too, by containing reservoirs of benthic organisms vital to the recolonization of sections downstream that may have become depopulated through pollution or from other causes. The following specific locations on the pipeline Prime Route are considered important for one of the three reasons stated.

Proximity to domestic or commercial fisheries:

0.5[1]	Mackenzie Delta - Harry Channel
18-20	Mackenzie Delta
23	Mackenzie Delta - Swimming Point
264	Mackenzie River, RMP 710
285	Mackenzie River at Fort Good Hope, RMP 685
356	Mackenzie River at Oscar Creek, RMP 584
421	Great Bear River and Mackenzie River, RMP 512 (Fort Norman)
582	Mackenzie River at River Between Two Mountains, RMP 334
599	Willowlake River
338.4[2]	Fish River
	West Channel, RMP 1010
	Husky Channel, RMP 990
407.5	Rat River
431.5	Peel River, RMP 950
457.5	Mackenzie River, RMP 902

Important fish overwintering areas with low flows:

356.9[1]	Oscar Creek
400	Vermilion Creek
508.1	Blackwater River
542	Ochre River
582.6	River Between Two Mountains
217.3[2]	Fish Creek
233.1	Firth River
338.4	Fish River
407.5	Rat River

Important fish spawning, rearing or feeding areas:

285.5[1]	Hare Indian River
318.3	Donnelly River
356.9	Oscar Creek
421	Great Bear River
508.1	Blackwater River
745.2	Trout River
807.7	Kakisa River
279.2[2]	Babbage River
316.3	Rapid Creek
338.4	Fish River
	Mackenzie River Delta - channels and lakes
407.5	Rat River

[1]Pipeline mileage, mainline.
[2]Pipeline mileage, Prudhoe Bay lateral.

Highlights

1. Very large quantities of waste and toxic materials will be involved in the proposed pipeline development (particularly the construction phase) and, in spite of various legislative safeguards, these give rise to concern for the quality and life associated with nearby waterbodies. Both in the north and elsewhere the past experience has been that the injudicious handling of waste and toxic materials can seriously impair water quality and its associated attributes.

2. The waste and toxic materials involved may be grouped into three broad categories displaying a generally decreasing potential for environmental harm. They are: (i) lubricants and fuels, (ii) paints and other specific-use chemicals, (iii) sewage, garbage, etc.

3. Eight main environmental concerns have been identified. These centre on fuel spills, lubricants, contingency plans, pipe-testing liquids, natural-gas leaks, fertilizers, sewage, solid wastes and on particularly sensitive aquatic environments. For each, the concerns are outlined and procedures, practices and consultive arrangements are indicated that could minimize or avoid environmental harm when final design is being formulated.

4. The fuel spill is the major concern, for altogether 65 million Imperial gallons will be handled and individual spills varying from some 400,000 gallons down to a few gallons are possible during the innumerable transportation, transfer and storage operations from one place or container to another. The Applicant has recognized the dangers and intends implementing the relevant federal and territorial regulations. In addition, numerous precautions are described in the text above that warrant consideration.

5. Of prime importance are adequate contingency plans, developed in consultation with federal (e.g. DIAND, MOT, DND and DOE) and territorial governments to cater for specific fuels and circumstances. In concept, contingency plans are more effective if preventive procedures are stressed at least as much as remedial measures. It is logical to structure contingency plans into separate ones for prevention, containment and clean-up procedures. The numerous aspects that warrant consideration for inclusion in the preparation of such plans are detailed in the main text above.

6. The acute toxicity of the high-temperature turbine lubricants even at low concentrations, suggests that special handling, storage and off-site disposal arrangements be implemented for such compounds.

7. Pipe-testing liquids are considered in detail

elsewhere in this Report. Care is needed in the disposal of warmed water to avoid thermal pollution or a changed pattern of spring break-up (of ice). The diluted or one-per-cent methanol is not considered to be of proven harmlessness, but indirect disposal arrangements could obviate this risk. For particularly sensitive areas, the dangers consequent upon a pipe rupture during testing could be reduced by shortening the length of pipe tested and by using water in lieu of a water-methanol mixture.

8. Natural-gas leaks arising from under-water pipe ruptures are likely to be rare and of little biological significance unless thick surface ice is present. In these circumstances the water's oxygen concentrations may be lowered, but better toxicological data on the impact are required.

9. Fertilizers used to assist revegetating the right-of-way pose no threat to aquatic organisms unless they are spread on water, ice, snow or the edges of streams, rivers and lakes.

10. It will be important to review location and design of sewage lagoons and effluent outfalls of package treatment-units on a site-by-site basis relative to possible pollution of waterbodies.

11. The accompanying list identifies pipeline crossings and wharf and stockpile sites where the possibility of pollution of the waterbody involves particular concerns relating to domestic or commercial fisheries; important overwintering fish areas; and important fish-spawning, rearing or feeding areas.

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9.9 AIR QUALITY, WITH PARTICULAR REFERENCE TO COMPRESSOR OPERATION

Introduction

Ever since John Evelyn wrote his classic "Fumifugium" over three centuries ago, man has been increasingly concerned with atmospheric pollution arising from domestic and industrial sources. An enormous technical literature now documents the problem. A variety of chemical substances may constitute the culprits responsible for deterioration of air quality, going all the way from the particles of carbon and tar in common smoke, through the gaseous products of fuel combustion such as sulphur dioxide, carbon monoxide, nitrogen oxides and unburnt hydrocarbons, to specific and distinctive industrial emissions. Moreover, polluted air may be far worse on some days than on others, depending upon wind-speed, temperature and other climatic factors. A particularly bad combination is a day with little or no breeze and a "temperature inversion", when emissions fail to disperse and linger in the surface layers of the air breathed by all.

How will the development of the proposed pipeline and its associated facilities affect the purity of the air and the components of the northern ecosystem dependent upon it? Will they remain unimpaired because the transmission of natural gas is a clean operation and involves no industrial processing? Or will there be harmful or annoying emissions? We already know that under some northern climatic conditions the exhausts from automobiles, chimneys and aircraft on runways generate ice fog: are the gas turbines at compressor stations along the 1,200-mile right-of-way likely to do likewise? These questions are examined in the following pages in the light of the available data. Attention is focussed on the potential effect on air quality resulting from compressor-station emissions because of their continuity of operation and the large quantity of emissions involved. Other aspects of pipeline development are also of some concern relative to air quality but are not discussed further in this paper. These include clearing and burning, vehicle and machinery exhausts during construction, and aircraft operation.

Applicant's and Other Data

Compressor Stations

The proposed installations are summarized in Table 1. Between the Alaska-Yukon border and 60°N. there are 24 compressor stations at 40- to 50-mile intervals along the Prime Route identified as CA-05 to CA-10 and M-01 to M-18. In the first five years of operation the Applicant proposes that 18 of these be equipped with compressor turbines: 17 each having one turbine of 30,000-hp and one, M-18, having two of 27,500-hp each. Fifteen of the compressor stations also have chilling turbines, one of 17,000-hp in each instance, except M-03 which has two. The Table shows that two stations—M-16 and M-17—have one turbine of 30,000-hp each, 14 stations have one of 30,000-hp plus one of 17,000-hp, one has two of 27,500-hp, and one has one of 30,000-hp plus two of 17,000-hp.

Station Emissions

Both the compressor and chilling turbines use a portion of the transmitted natural gas as fuel. The Applicant indicates that the gas is clean burning and the concentrations of nitrogen oxides, sulphur dioxide, carbon monoxide and unburnt hydrocarbons in the exhaust are not expected to exceed 220, one, ten and five ppm respectively. For stations

TABLE 1

Numbers and Horsepower of Compressor and Chilling Turbines Proposed at Various Canadian Stations (north of 60°N.), with Associated Airfields, Helipads and Access Roads to Nearby Highways

Station	Compressor Turbines	Chilling Turbines	Airstrips* and Helipads	Access Road to Highway Nearby
CA-05	1 x 30,000	1 x 17,000	6,000	
CA-06			2,400	
CA-07			2,400	
CA-08			2,400	
CA-09	1 x 30,000	1 x 17,000	6,000	
CA-10			H	
CA-10A (communication tower)				
M-00 (metering station)			H	
M-01			2,400	
M-02			H	Yes
M-03	1 x 30,000	2 x 17,000	6,000	
M-04	1 x 30,000	1 x 17,000	6,000	
M-05	1 x 30,000	1 x 17,000	2,400	
M-06	1 x 30,000	1 x 17,000	H	
M-07	1 x 30,000	1 x 17,000	H	Yes
M-08	1 x 30,000	1 x 17,000	H	Yes
M-09	1 x 30,000	1 x 17,000	H	Yes
M-10	1 x 30,000	1 x 17,000	H	Yes
M-11	1 x 30,000	1 x 17,000	2,400	Yes
M-12	1 x 30,000	1 x 17,000	H	Yes
M-13	1 x 30,000	1 x 17,000	H	Yes
M-14	1 x 30,000	1 x 17,000	2,400	
M-15	1 x 30,000	1 x 17,000	H	Yes
M-16	1 x 30,000		H	Yes
M-17	1 x 30,000		2,400	
M-18	2 x 27,500		6,000	

*Lengths are shown in feet.

having one compressor and one chilling turbine totalling 47,000-hp, the weight of exhaust gases emitted per hour amounts to 1.8 million lb, of which about 49,000 lb or 5,000 Imperial gallons (6,000 U.S. gallons) are steam. These exhaust gases are vented at the very high temperature of 600°F, contributing 300 million Btu/hr to the atmosphere. Data are not provided for individual

station emissions, but if emissions are assumed to be roughly proportional to turbine horsepower, approximate figures for steam outputs can readily be calculated for stations M-16 and M-17 (30,000-hp), M-18 (55,000-hp) and M-03 (64,000-hp). In addition to the steam emitted whose hydrogen has been exclusively derived from the combusted methane and other hydrocarbons in the natural gas, there will be steam derived from the normal water vapour contained in the air that has been passed through the turbines to combust the natural gas. This is a variable quantity, of course, being dependent upon particular humidity conditions. However, a calculation for winter conditions has shown this extra steam would add only 3 per cent to the 5,000 gallons. Details for stack heights at stations do not seem to be available but the heat of the exhaust discharge would be expected—as the Applicant says—to take the plume rapidly upwards.

The natural gas to be combusted in the turbines is expected to contain from 85 to 95 per cent of methane—ethane, propane, butane, pentane and hexane making up most of the remainder with carbon dioxide and nitrogen amounting together to 1.65 per cent (Sect. 8.b.2.1.1, p.12). A sulphur content is not shown, but the content is expected to be very small and within the limits usually stipulated by carriers to prevent pipeline corrosion (*see* topic "Environmental Safety of Pipeline"). Some unburnt natural gas is emitted or vented from stations. This is further discussed in the above cited topic, but a point of particular importance is that compared with unburnt hydrocarbon emissions from oil and gasoline engines, those from natural gas are low in carbon atoms and less dense than air.

Meteorological Data

In broad terms, the climate along the proposed Prime Route varies from coastal Arctic near the Beaufort Sea to interior sub-Arctic along the Mackenzie Valley. The predominant air mass influencing the Mackenzie Valley region is continental Arctic, although modifications to cold maritime Arctic, maritime Arctic, maritime Polar, and maritime Tropical airs of increasing moisture and temperature do occur, but with decreasing frequency. During the winter, the huge snow-covered Polar Basin and Northwest Territories are the source of the dominant continental Arctic air masses.

Mean daily January temperatures range from about -15^{o}F at Fort Simpson to about -20^{o}F northward along the Mackenzie Valley from Norman Wells to the vicinity of Inuvik and Fort McPherson. The mean daily maximum and minimum temperatures are generally 5 to 10 degrees warmer and colder than these values respectively. In July, the corresponding figures are 60^{o}F in the southern portions of the Valley to 45^{o}F on the Yukon coast, with daily mean minima and maxima varying from these by some 10 degrees. The numbers of days a year with a daily temperature below 32^{o}F varies from 200 near 60^{o}N to over 250 on the Yukon coast. Mean annual precipitation at the same locations ranges from 15 to under 5 in.

Mean hourly wind speeds decrease from about 12-13 mph at the coast to 6-8 mph in the southern portions of the Mackenzie Valley. The duration of winds varies appreciably from summer to winter, periods of calm being very much longer in winter. Inuvik, for example, shows calm periods totalling 88 hours for November, 65 hours for January, but only 8 hours for July. Farther up the Valley at Norman Wells and Fort Simpson, calm periods total 55 hours in January, but only 10 to 15 hours in July. Similar trends exist in the light-wind (1-to-9 mph) category.

A typical feature of Arctic winter mornings is a ground-surface-based temperature inversion, which is caused by the negative radiation balance over the vast snow and ice surfaces present during the greater part of the year. Inversions play a major role in atmospheric pollution and the available records (Burns, 1973) for the Mackenzie Valley show that inversion conditions are present in winter from about one-half to two-thirds of the time. This is not to say, however, that pollution automatically follows, for inversions vary in intensity, wind speed is critical, and pollutants not only vary in offensiveness, temperature of emission and dispersibility, but may be absent because none is being generated.

A special case of pollution in northern latitudes is ice fog, which is associated with populated areas whenever climatic conditions favouring pollution prevail. Ice fog is a reduction in visibility caused by concentrations of suspended water particles. The particles are formed by the condensation of water vapour onto hydrocarbon nuclei, originating as combustion by-products (Csanady and Wrigley, 1973). As the maximum amount of water vapour that can be held in air drops drastically in the sequence: 0.0304, 0.0147, 0.0067, 0.0028 and 0.0011 Imperial gallons per 1,000 cu ft as the temperature drops through the gradation: 32, 14, -4, -22 and -40°F, it is easy to see that under suitably cold climatic conditions, the strong possibility exists that any water-vapour emitted by the combustion of fuel will immediately form ice fog. Indeed, the working guide is that ice fog can occur at -4°F, is increasingly likely to form when temperatures reach -22°F, and will almost certainly form when they drop below -40°F. How probable are such temperatures in the Mackenzie Valley?

An extract of Burns' (1973) data is shown in Table 2. Percentage probabilities are given for the mean daily temperatures at Aklavik and Fort Simpson, being less than certain temperatures at the mid-points of six winter months. It is difficult to summarize such data, but they clearly demonstrate

TABLE 2

Percentage Probability of Mean Daily Temperatures Being Less Than Specified Temperatures

Locality/Month	Jan	Feb	Mar	Apr	Nov	Dec
		0°F				
Aklavik	86	91	76	31	51	85
Fort Simpson	97	67	36	*	39	78
		-20°F				
Aklavik	34	37	15	*	20	24
Fort Simpson	44	19	*	*	6	14
		-40°F				
Aklavik	9	*	*	*	*	6
Fort Simpson	6	*	*	*	*	*

*Months with all probabilities > 95% or < 5%.

that temperatures suitable for ice fog formation occur somewhere between one-half and one-tenth of the time during the four severest winter months.

An example cited by Csanady and Wrigley (1973) for the effects of an ice fog is Fairbanks, Alaska, where ice fogs last from one to eight days and cover from 5 to 10 square miles. The water vapour output of this city in 1969 was around 30,000 Imperial gallons per hour, or six times greater than the 5,000 gallons per hour output of most compressor stations.

Concerns

General

To put the environmental concerns on air quality into perspective it is necessary to say first that the Applicant proposes no processing or refining over the entire pipeline route. Hence, except for the rare occurrence of a pipeline break, major emissions during operation arise only from compressors. On the other hand, further emissions can be expected from the gas processing plants that will feed the pipeline. The second point is that four sorts of emissions arise—natural gas from normal operational venting at compressor stations, exhaust gases from the combustion of natural gas at compressor stations, steam derived in the same way, and lastly, unburnt natural gas or burning natural gas escaping anywhere along the pipeline route through pipe rupture. The first three of these emissions take place at points separated as widely apart as 40 to 50 miles. No community is nearer than 25 miles to these points and where access roads link a compressor station with a highway (mostly the Mackenzie, but the Liard in one instance), the distance is from three to ten miles. Normal emissions, therefore, are likely to have the potential to affect only small groups of people, and wildlife or plants in the immediate vicinity of compressor stations. Although pipe breaks can occur anywhere, they occur only rarely.

Emissions Other than Steam

These have been discussed in detail elsewhere in this Review (*see* topic "Environmental Safety of Pipeline"). Essentially, the normal venting of unburnt natural gas and venting or flaring of lesser volumes of propane are considered by the Assessment Group to pose little, if any, danger to people or animals, unless exceptional weather and topographic conditions prevail. In a similar way, the exhaust gases emitted from the combustion of natural gas and propane are seen to pose no danger to people and animals. On the other hand, the pattern of gas dispersal and the sulphur dioxide content are felt to be insufficiently documented to be sure at this stage that effects upon nearby sensitive vegetation will not occur. It may be noted that following the 1971 federal Clean Air Act a number of National Ambient Air Quality Objectives have been formulated (Edgeworth, 1974) in respect of sulphur dioxide and other by-products of fuel combustion. Moreover under the same Act, national emission objectives for a variety of industries and potential pollutants are in process of formulation and promulgation. By the final design stage, therefore, the Applicant might have an opportunity to indicate how adequately planned emissions from the compressor stations accord with the appropriate federal guides.

Steam and Ice Fog

The production of ice fog has been recognized by the Applicant (Sect. 8.b.1.4.3, p.15; Sect. 14.d. N.7.4.2, p.7) and, at first sight, the rate of production of steam from compressor stations and the frequency of winter occasions when ice fog can form give rise to appreciable concerns. With

compressors working continuously, 5,000 gallons per hour represents 240,000 gallons every two days and a little over a million gallons a week. The analogy with Fairbanks and with other communities raises the question whether comparable or perhaps somewhat smaller ice fogs will come to characterize the environs of compressor stations and constitute a threat to nearby air and road communication links.

A critical examination of the various factors does not enable us to dismiss these concerns altogether, but at least they appear not so serious. In the first place, the analogy with Fairbanks and with other populated centres is not altogether apposite, because the fuel-combustion exhausts which provide the hydrocarbon nuclei on which the ice-fog crystals form, contain unburn hydrocarbons that are higher in carbon atoms and denser than air compared with those derived from natural gas. Moreover, they are emitted at a lower temperature and at a lower height. The important difference between the populated centres and the compressor stations is, therefore, that regardless how intense an inversion, how low the temperature, and how calm the air, any hydrocarbon nuclei derived from compressor stations will diffuse to the upper atmosphere. In addition, the high temperature of emission at compressor stations—600°F—will cause the plume of steam and other exhaust gases to rise rapidly. In this way the condensation to water vapour and then to ice crystals is more likely to be at an altitude where the wind speed and chances of dispersal are greater.

Be this as it may, a compressor station is emitting a considerable amount of steam. In two days at a temperature of -22°F, for example, enough is emitted to fully saturate the air over 15 square miles of surface to a height of 200 feet. That is, if the air was not already saturated with water vapour and could hold the additional emission. At -40°F, the area becomes 40 square miles. It seems inevitable, then, that under some winter conditions quite large clouds of ice fog will be associated with compressor stations. Other things being equal, one may say that conditions are likely to be worse at M-03, where there is a horsepower of 64,000, and at M-18, where there is 55,000-hp, compared with the usual figure of 47,000-hp. Similarly, less serious conditions should obtain at M-16 and M-17, where there are turbines of only 30,000-hp. At times, therefore, there might be navigational problems associated with the use of the Applicant's airstrips at compressor stations, especially if they are downslope from the turbines. On the other hand, an examination of the Applicant's photomosaic alignment sheets suggests that most airstrips are fairly well located in relation to topographic features. No problems are seen for more distant government airports, and no serious disruptions to transport are thought likely on the nearby Mackenzie Highway (M. Berry, Atmospheric Environment Service, Environment Canada, pers. comm.). Without doubt, a more detailed examination of the characteristics associated with each compressor station, supported by on-site tests, could better define the problems associated with each station, but on the information currently available the Applicant's proposals do not appear to entail generating ice fogs that will affect public transportation or communities.

A point that must also be taken into account in the over-all analysis is that if natural gas is used directly or indirectly—via electricity generators—for community centres as an energy-source alternative to oil (*see* topic "Community Energy Alternatives"), there could well be a decrease of ice fogs associated with such centres.

Highlights

1. North of 60°N. the climate of the proposed

pipeline route is characterized by winter periods of very low temperature, with little or no wind and with ground-surface-based temperature inversions.

2. Such climatic conditions inhibit the dispersal and removal of emissions in the atmosphere and lead to a deterioration in air quality in the vicinity of pollution sources. A special case of pollution in northern population centres is ice fog, formed because the very cold and calm air cannot contain the amounts of water vapour and steam generated by the combustion of hydrocarbon fuels.

3. The Applicant proposes no processing or refining over the length of his proposed route; hence, except for the possible occurrence of a pipeline break his operational emissions arise from compressor stations.

4. Compressor stations are located 40 to 50 miles apart and are never closer than 25 miles to a community. Access roads linking compressor stations to highways are usually three to 15 miles long. Compressor emissions, therefore, affect only small groups of people and plants and animals in the immediate vicinity of stations.

5. Three types of emissions occur—unburnt natural gas, exhaust gases, and steam. The venting of unburnt natural gas is normally not considered to pose any danger to people or animals.

6. The exhaust gases emitted similarly pose no threat to people and animals, but the patterns of gas dispersal and sulphur dioxide content are insufficiently documented to be sure that localized effects would not occur on sensitive vegetation. The National Ambient Air Quality Objectives for sulphur dioxide formulated under the 1971 federal Clean Air Act, together with appropriate specific-industry guides for emissions issued under the same Act could serve to assist the Applicant by the time final design proposals have crystallized.

7. The Applicant recognizes that ice fog will form under appropriate winter climatic conditions because of the large amounts of steam being con-inuously generated from the turbines of the compressor stations. The available data have been critically analyzed and although on occasions clouds of ice fog centred on compressor stations seem inevitable, it is not thought that serious difficulties will be created in the air and road communication links for the general public. Other things being equal, stations M-03 followed by M-16 and M-17 seem more prone to ice fog by reason of the greater horsepower totals at these stations, but the nature of the problem would be better delineated by studying each compressor station individually, with possible supporting on-site field tests.

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9.10 AESTHETICS

Introduction

Aesthetics is concerned with the qualities that give pleasure to the senses. Although sight, sound, smell, touch and taste would all fall within this conventional concept, aesthetics is often considered to be concerned primarily with visual qualities, man's other perceptions receiving only minor attention. Both the Applicant and the Assessment Group interpret aesthetics in this way, but the other components, such as sound and smell, are by no means forgotten and are dealt with in other parts of the report.

Visual qualities constitute a complex blend, including features of the climate, topography, geomorphology, geology, soil, vegetation, waterbodies, wildlife and man's artifacts. Within the last-named comes the pipeline development with its many intrusions into the environment—the clearing and construction on the right-of-way, the establishment of a different vegetation on the right-of-way, borrow-pit excavations, the building of ancillary facilities, and the construction of airstrips.

How are these intrusions to be judged? Should they largely be ignored because they occur in remote areas or should complete restoration of visual qualities of a largely wilderness area be the aim? Is there some priority in visual qualities, that would place more emphasis on some environmental characteristics than others? And how generally acceptable to different audiences would particular priorities in visual qualities be?

What is visually acceptable or attractive can vary enormously among peoples, places and periods. To many, a mosaic of fields is no violation of the unbroken prairies it replaced. To many, the ruined artifacts of previous cultures—including engineering structures—warrant careful preservation, however incongruous such artifacts must have been in their original settings. Perhaps the most striking paradox occurs in attitudes to trees, when the clear-felling of an existing forest is condemned with a vigour equalled only by the objections raised when an open area is afforested. How, then, against a background that appears so subjective and impermanent can standards be set to appraise the aesthetic acceptability of a pipeline?

As a general principle, a development seems aesthetically acceptable if it fits with what is considered at the time to be a desirable development, however incongruous it might be viewed at other times. The aesthetic attitude of a particular day-and-age, therefore, is critically important. Today, the guiding fashion is that an engineering development does not dominate the landscape by an assertive presence, but blends as inconspicuously as possible into the natural scene. There are, indeed, well developed approaches and techniques to achieve this, and it is the Applicant's proposed use of them that forms the substance of one of the Assessment Group's comments.

Complete restoration of a former situation is usually impossible and insistence upon it would stifle development and progress almost anywhere. Therefore, in this regard one looks to see whether a reasonable compromise is being struck, whether the Applicant has kept his disturbance to a minimum, whether he has displayed concern for implementing the better available restorative measures, whether attention is being paid to the particular nature of local visual characteristics, and that areas of special natural beauty are earmarked for special attention.

In judging the Applicant's proposals the Assessment Group has endeavoured to take into account the

different publics concerned, be they the native peoples with their traditional interests, other northern residents or tourists seeking a wilderness environment that is becoming ever rarer in other parts of Canada. Also considered has been the improved access by air, road and water, opening up areas and vistas that today remain relatively hidden.

The above criteria, therefore, are those used by the Assessment Group in examining the Applicant's proposals for minimizing visual impact upon the aesthetic values of the Yukon and Northwest Territories. As is explained in detail below, the Group finds some features commendable, but concern is felt over certain aspects for they appear to underestimate how increasingly visible the development will soon become.

Applicant's Data

The visual aspects of the pipeline route have been examined by the Applicant using the recognized physiographic regions of the Yukon and Northwest Territories as a base. Seven basic areas having significantly different visual and aesthetic experience have been selected by the Applicant; these are discussed in Section 14.d.N.4.5.

The Applicant has established procedures to be followed to"...achieve aesthetically desirable results" (Sect. 14.d.N.6.3.9). The Applicant's attitude and response towards "typical situations" not specific to any physiographic region are as follows:

(i) to separate visually the pipeline corridor from the Mackenzie River and the Mackenzie Highway;

(ii) to use tree cover, terrain and colour and texture to lessen the visual impact of above-ground structures;

(iii) to align clear-cut rights-of-way along lower slopes; and

(iv) to use revegetation as an aid in blending the pipeline in with its surroundings.

The Applicant takes the approach that these aesthetic considerations will provide, both during final design and construction, the basis for maintaining the essential quality of the visual landscape upon completion, and for creating a subtle blending of the pipeline in the natural landscape with time (Sect. 14.d.N.7.5).

The impact of the pipeline on aesthetics is discussed in Section 14.d.N.7.5 within the context of the physiographic setting (Sect. 14.d.N.4.5) and "principles of mitigation" are stated in Section 14.d.N.6.3.9. The Applicant recognizes that there will be an unavoidable alteration of a limited area of land during construction and that the nature of the pipeline route precludes reclamation to a predisturbance condition, and this has figured in his assessment of impact.

The Applicant concludes (Sect.14.d.N.2.1.5) that any judgment of aesthetic impact is subjective and conditioned by the locale and the expectations of the viewer. He also concludes that the degree of visual impact is dependent upon the extent of public exposure and, because the pipeline will be seen by relatively few people, its impact on the viewing public will be of minor proportions.

Concerns

1. The following aspects of the Applicant's proposals relative to aesthetics are of concern in terms of both the principles involved and their implemen-

tation.

(i) The judgment of aesthetic impact, as the Applicant has noted, can only be subjective and based on the viewer's expectations and personal evaluation; this complicates and makes difficult any evaluation. It would be appropriate, therefore, for the Applicant to attempt to evaluate the aesthetic impact of his project from the points of view of others, as well as his own. The point of view of the local people along the proposed route is particularly relevant in this regard, as also is the view of "southern" Canadians who are increasingly concerned over wilderness areas.

(ii) The Applicant makes the following statement in Section 14.d.N.2.1.5 "The degree of direct visual impact depends on the extent of public exposure. In the remote and largely undeveloped territory through which it passes, the pipeline development will be seen by few people, and the impact on the viewing public will be of minor proportions." This statement conveys the unfortunate impression that remote undeveloped areas are of little concern in terms of visual aesthetics. The impact on an individual viewer is no less if he is the only one who sees the pipeline, or if thousands see it. The Assessment Group considers that all areas along the pipeline route are of aesthetic concern, regardless of the number of people that currently pass through them or of their intrinsic "interest" level. Moreover, areas that are remote or inaccessible today could be much more in the public view in the future.

(iii) In his assessment of aesthetic impact, the Applicant has considered only visual experience. "Other aesthetic considerations" are mentioned (Sect. 14.d.N.7.5) but are not explained or considered. The impact of noise, for example, has not been considered directly in terms of aesthetic experience, but only peripherally in relation to disturbance of animal populations.

(iv) There has been little consideration by the Applicant of the aesthetic impact from other than the ground level; aerial or elevated views deserve more attention. Travel, except in southern parts of the two territories, is primarily by aircraft, much of it in small aircraft at low elevations. Cleared areas such as seismic lines, highways or pipeline rights-of-way, because of their linear nature, are highly visible and, to many observers, intrusive.

(v) In Section 14.d.N.2.1.5 the Applicant contends that in tundra regions the revegetated ditch crown will be absorbed by the vast scale of the open landscape. If the ditch crown remains elevated (as the Applicant expects) plant-species composition will also differ from the adjacent tundra and will remain different for some indeterminate period as vegetational succession proceeds. These differences in species compositions will result in differences in colour and texture which, coupled with the unnaturally straight lines of the ditch crown, will result in a highly visible surface feature. Tracks resulting from a seismic program conducted in the summer of 1965 on the Tuktoyuktuk Peninsula are still highly visible, in large part because of differences in vegetation; they have not been absorbed by

the "vast scale of the landscape."

(vi) The Applicant suggests that a cleared right-of-way in forest sections will provide visual relief from the unbroken forest canopy. The Assessment Group questions this concept. The numerous seismic lines crossed by the Mackenzie Highway will provide sufficient visual relief of this type without the added "benefit" of of a pipeline crossing. Crossings should be as unobtrusive as possible. Some thought is required of the Applicant towards ways of minimizing this aspect of visual impact. Moreover, as noted previously, much travel in the north is by small aircraft at low elevations; man-made features are intrusive.

2. The Applicant has indicated (Sect. 14.d.N.6.3.9, p.12) that "special care" will be taken to minimize visual impacts in areas of public contact such as roads, river valleys and communities. The Assessment Group recognizes the priority of such areas, and in addition would draw attention to the importance of identifying and to applying further special care in areas of high aesthetic interest. For instance, in contrast to the "transportation corridor" section of the pipeline route on the east side of Mackenzie River, the Yukon Coastal Plain section displays unique wilderness values that deserve to be protected. The topic section of this report dealing with "Pipeline Impact in Valleys" includes mention of the particular aesthetic values in valleys. Other areas of high aesthetic interest are identified in the topic section "Recreation Areas, Parks and Land Reserves" in which a need is recognized for further review of possible adverse impact of pipeline development on potential park and recreation sites and for communication between the Applicant and other interested parties concerning proposed land reserves.

3. The Applicant has outlined general principles (Sect. 14.d.N.6.3.9) that will be employed during the final design and construction of the pipeline to minimize aesthetic impact. The Assessment Group has no criticism of the proposed principles but notes that information has not been provided as to how they are to be implemented nor on the degree of importance attached to such aesthetic consideration. In the opinion of the Assessment Group considerable benefit could result if the Applicant were to obtain the views of local people and other interested groups on the implementation of aesthetic principles and their application in specific geographical areas during the planning and construction phases of the project.

Highlights

1. This paper deals principally with the visual qualities of the environment. Three basic approaches are: that the pipeline and associated facilities should blend as much as possible into their largely wilderness surroundings, that all areas are of visual importance, and that some areas are of greater visual interest than others.

2. The Assessment Group questions some of the Applicant's views on aesthetic aspects of his proposals and notes that remote areas may become accessible in the future and that visual effects from aircraft are as important in the north as the view from the ground.

3. The pipeline and its facilities are likely to be highly visible in tundra regions. One should not expect that blending will be rapid or that the facility will be absorbed by the vast scale of the landscape.

4. The Assessment Group draws attention to the

importance of identifying and protecting areas of high aesthetic interest, including those referred to in the topic "Recreation Areas, Parks and Land Reserves". The unique wilderness value of the Yukon Coastal Plain is of particular concern.

5. Implementation of aesthetic principles in final design and construction could afford an opportunity for the Applicant to react to the views of local people and other interest groups.

9.11 ENVIRONMENTAL SAFETY OF PIPELINE

Introduction

Modern technological developments often raise concern and even fear in the minds of a public that has to live in their proximity. This is particularly true for complex engineering facilities and two inherent features of the proposed pipeline could generate anxiety if not critically examined and put in perspective.

The first is the enormous volumes of highly flammable and explosive gas being handled, and the second is that each of the numerous compressor stations along the right-of-way has gas-turbines that in power, fuel consumption, and noise emission correspond to modern jet-aircraft engines.

In spite of the fact that throughout the world the transmission of natural gas in thousands of miles of pipeline and its processing in innumerable industrial plants proceeds safely and without danger to the public, we must still ask what procedures are proposed in the present instance to ensure the safety of the people of the Yukon and Northwest Territories. This is not to say, of course, that the well-being of other constituents of the environment is to be overlooked. These are examined in detail in other sections of the Review. In the following paragraphs the Assessment Group is specifically concerned with gas-release, leaks, gas-toxicity, fire, explosion and noise in relation to the public. It is assumed that appropriate codes and safeguards will apply as far as employees of Canadian Gas Arctic Pipeline Ltd. are concerned.

No serious threats to people are seen either from normal operational procedures or from possible accidents, but certain data could be improved for the final design stage.

Relevant Data

The natural gas to be carried is expected to contain from 85 to 95 per cent of methane—ethane, propane, butane, pentane and hexane making up most of the remainder with carbon dioxide and nitrogen amounting together to 1.65 per cent (Sect. 8.b.2.1.1., p.12). A sulphur content is not shown but is not entirely absent as the emission of sulphur dioxide is acknowledged (Sect. 14.d.S.15.2.2, p.3) when the gas is combusted in compressor turbines. However, the amount of sulphur in the gas would not be expected to exceed the maxima usually stipulated by carriers (Hangs, 1962). The predominant ingredient of natural gas, methane, is present in the normal atmosphere in very small concentrations, and derives one of its alternative names, marsh gas, from the fact that it is generated in marshy areas through the decay of vegetation.

Methane is much lighter than air, hence in open spaces quickly diffuses upwards. Its very low boiling point—minus 259°F—means that under no climatic extremes in the north could it condense to a liquid and contaminate soil and water. Its most dangerous property is that when mixed with air in proportions ranging from 5 to 14 per cent it is highly explosive and flammable. Methane is not toxic, but could asphyxiate by its exclusion of oxygen. It is colourless and odourless, hence cannot be seen or smelt. None of these properties, however, has prevented a rapidly increasing and successful use of natural gas throughout the world for domestic, commercial and industrial purposes.

The natural gas will be pumped through the buried pipeline at a rate rising ultimately to around 4.5 billion cu ft/day at a pressure of around 1,700 lb/sq in. The pipeline incorporates the most

up-to-date advances in pipeline technology, metallurgy, manufacturing construction methods, and procedures for monitoring, control and maintenance. It has to comply with both the National Energy Board's regulations and the Canadian Standards Association's standards for gas pipelines, which are designed among other things to ensure maximum safety to the public.

Between the Alaska-Yukon border and 60°N. there are 24 compressor stations along the Prime Route at 40- to 50-mile intervals (Sect. 13.a.2.2, Drawing Number 4-0214-1004; Sect. 8.b.4, Sheet Numbers I, 1-10) and each station has a 30,000-hp gas-turbine compressor (Sect. 14.d.N.5.2.2, p.5). These compressors pump the natural gas along the pipeline and are fuelled by a portion of the natural gas itself. For normal operation a compressor appears to emit some 0.9 million lb of exhaust gases/hr at a temperature of 600°F. These gases contain nitrogen, oxygen, carbon dioxide and steam, with concentrations of nitrogen oxides, sulphur dioxide, carbon monoxide and unburnt hydrocarbons not exceeding 220, one, ten and five ppm respectively (Sect. 14.d.N.7.4.2, p.7). The steam component is equivalent to 3,000 gallons of water/hr. In addition to this emission, unburnt natural gas is released during regular maintenance when compressors are shut down and started up. For shut-down, 200,000 cu ft of unburnt natural gas are released and for start-up 150,000 cu ft. This operation could occur several times a year from each compressor station.

Between the Alaska-Yukon border and 60°N. there are in addition 17 chilling turbines fuelled by natural gas and using propane as a refrigerant. Propane is not released in the same way on shut-down or start-up, but a part of the system is vented and the propane release is flared. There are the usual exhaust gases from the natural-gas combustion but as the chilling turbines are each 17,000-hp, proportionately smaller volumes of exhaust gases would be emitted compared with the 30,000-hp natural-gas compressors.

Apart from the above routine release of natural gas into the atmosphere, there could be releases caused by emergency shut-downs and pipeline ruptures. Emergency shut-downs appear to necessitate rather higher volumes of unburnt natural gas being released than routine shut-downs, but presumably emergency shut-downs would be much less frequent. Rather larger amounts of gas, again, could result from pipeline ruptures and in such cases the gas could ignite. Such breaks are rare, however, and the monitoring system would quickly detect a pressure drop, thereby actuating the block valves and isolating the pipeline section affected. It is disconcerting to read, however, that gas could escape for five hours (Sect. 14.d.S.17.4.2, p.10), for this might mean that some 250 million cu ft of natural gas would escape before the gas at high pressure in the 20-mile stretch between block valves dropped to atmospheric pressure.

Apart from equipment to be used during construction and vehicles and aircraft to be used more routinely during the main operational phase of pipeline development, the most important source of continuous noise will be from the compressor stations. The Applicant provides estimates of the noise levels that can be expected from a compressor at a station's boundary when conventional silencing is employed (Sect. 8.b.1.4.3, p.17). These noise levels do not include noise of gas release during shut-down (blow-down) but range from 47 to 79 decibels (dB), depending upon frequency. They are said to be similar to those for existing plants elsewhere in Canada, and although it is very difficult to classify noise levels on Cohen's Scale (Anon., 1972), these could be regarded as ranging from "quiet" at 50 dB to somewhere between "moderately loud" at 75 dB and "very

loud" at 95 dB. The Applicant acknowledges that additional measures to abate the noise levels may be necessary for compressors in sensitive locations.

Concerns

General

Although the danger to people and property along the pipeline route will be small and dangers to operational and maintenance staff will be low, nevertheless, owing to the high operating pressure in the pipeline system, the potential for a rupture or accident of explosion or fire still exists. The causes of failure can include manufacturing defects, corrosion, incorrect installation and construction procedures, improper operation, natural hazards such as slope failure, or damage by external factors such as heavy excavating equipment.

Natural Gas and Propane Venting

The routine venting of natural gas, to the extent for which volume figures are available, will probably pose no dangers to people, animals or plants in open spaces on most occasions, for the gas will rapidly diffuse upwards. It must be observed, however, that 200,000 cu ft of natural gas when diluted with air to become a non-explosive mixture would occupy more than an acre of surface area to a height of 100 ft. Concern arises, therefore, for venting in locations where there would be restricted air circulation, on the numerous very calm occasions in the Mackenzie Valley (*see* topic "Air Quality"), and for emergency or other shutdowns when rather higher volumes of gas would be released. The potential danger would not be to communities (for they are all more than 25 miles from compressor stations) but to people should they happen to be in the vicinity in case of explosion. Toxicity is not considered to be a significant problem. Appropriate monitoring, however, should indicate the safety margins required around stations. Volumes for propane to be flared are not available but they are thought to be much less. Although its flammability is less, propane is denser than air and if released could remain undispersed in hollows under calm conditions. The potential danger from propane needs to be better documented.

Exhaust Gases

No component of the exhaust gases appears to present a danger to human or animal health, although under some conditions poor dispersal could constitude a nuisance. The picture for plants, especially lichens and bryophytes, and for soil is less clear because the quantities of sulphur dioxide emitted and the patterns of their dispersal are not known. This situation should be better documented, but any adverse effects would probably be quite localized. The emission of water vapour is discussed elsewhere (*see* topic "Air Quality").

Pipeline Breaks

For pipeline breaks, quite large volumes of natural gas could be released, with considerable hazard of fire or explosion under appropriate conditions of weather, topography and gas-air mixtures (Beak Consultants Ltd., 1974). Clearly, the hazard would be greater in valleys or canyons in calm weather, and during dry summer conditions when a forest or vegetation fire might be started. As a break is not impossible at any point along the pipeline, any location is at risk. In absolute terms, however, breaks are very infrequent and are less likely to occur in the more stable terrain types.

Forest Fires

Fires caused by non-pipeline sources could normally cross the right-of-way without danger to the buried pipe. The main hazard of such a fire would be the possible destruction of vegetation on the right-of-way, leading later to thawing of the permafrost, erosion and ground instability. Compressor stations stand on concrete or granular pads on some 40 acres of cleared ground. The possibility of damage to these stations from forest fires is remote, therefore, and the same applies to compressor-station block valves, which are well within the cleared areas, and to line block valves, which are mostly underground.

Accidental Damage

Because of the heavy wall thickness of the pipe proposed by the Applicant for the Canadian Arctic Gas project, passage of light vehicles over the buried pipe or the impact of ordinary rifle bullets against above-ground parts of the pipe would not endanger it and, in turn, environmental components and people. Of course, precautions to protect the pipe are needed where heavy machinery will cross the pipe or operate close to it.

Noise

Compressor stations are too far away to disturb people in communities. However, noise may be disturbing at camp locations used by native people and at tourist recreation or campsites along the highway or rivers. The Applicant has already planned to review the noise abatement measures necessary for each compressor station, and this proposal seems the one best able to meet the requirements of each situation.

Highlights

1. In spite of the generally safe operation of thousands of miles of natural gas pipelines in many countries of the world, the highly flammable and explosive properties of the gas, on the one hand, and the nature of the large compressor and chilling turbines, on the other, can engender very genuine anxiety among people living in the proximity of the proposed development.

2. Perhaps the prime public concern would be that some accident to the pipeline or its facilities would cause a major disaster to the people, animals or plants of the area. Modern pipeline technology makes the possibility of pipeline rupture very unlikely, and the built-in monitoring devices would ensure only localized gas escape or fire. The gas is not poisonous and would normally diffuse rapidly upwards, while fires would spread only if the climatic and vegetation conditions were exceptional.

3. Natural forest fires and movement of vehicles or machines are unlikely to affect the buried pipeline or the well-buffered facilities.

4. People might also be concerned over the dangers normal operating procedures might entail. Here, most attention would be focused on the compressor stations, although their remoteness from communities would mean that only small groups of people could be directly affected. The normal venting of unburnt natural gas and the venting and flaring of lesser volumes of propane pose little, if any, danger to people or animals, unless exceptional weather and topographic conditions prevail. There does seem to be a need, however, for better quantification of these data.

5. The exhaust gases emitted from the combustion of natural gas and propane pose no danger to

people and animals, but the pattern of gas dispersal and the sulphur dioxide content are insufficiently documented to be sure that localized effects would not occur on nearby sensitive vegetation.

6. Appropriate silencing should minimize any nuisance effects noise from compressor and chilling turbines might have on people as well as animals. The Applicant's proposal to examine the circumstances of each station in this regard is supported by the Assessment Group in view of the difficulty of making generalized noise-abatement recommendations.

Literature Sources

Anon., 1972. "Health Hazards of the Human Environment", World Health Organization, Geneva.

Beak Consultants Ltd., Calgary, Alta., 1974. "Gas Pipelines in the Mackenzie River Valley: Estimation of Fire and Explosion Hazards Caused by Pipeline Rupture", prepared for the Task Force on Northern Oil Development, Rept. 74-3.

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ROUTES AND CORRIDORS

CHAPTER 10

CORRIDOR CONSIDERATIONS, PRIME ROUTE

10.1 CORRIDOR

The "Expanded Guidelines for Northern Pipelines" identify certain pipeline corridors, for trunk pipelines, "to carry oil and gas to southern markets from sources in this part of Canada and/or from the Alaska north slope." The "Prime" pipeline routes proposed by the Applicant fall within these corridors.

The corridor section of the Guidelines also expresses concern over the spacing (distance) between one pipeline and the other, the routing of oil and gas pipelines close to other transportation-communication systems or communities, and the resulting interactive and cumulative social, environmental and terrain-engineering effects. Emphasis is placed on the importance of the first pipeline in influencing the location of the second pipeline and thus in shaping the transportation corridor system and in moulding the environmental and social future of the region, and the Guidelines ask for "assessment of the suitability of the Applicant's route for nearby routing of the other pipeline, in terms of the environmental-social and terrain-engineering consequences of the other pipeline and the combined effect of the two pipelines." The "Requests for Supplementary Information" have asked the Applicant to respond in greater detail regarding this matter; the Assessment Group has not dealt further with the topic here, pending review of the Applicant's reply.

The corridor concept also involves interrelationship of the pipeline with other transportation systems in general and with the Mackenzie Highway in particular. A general discussion of pipeline effects on transportation appears in the socio-economic part of this report and "Pipeline-Highway Interaction" is reviewed in the present chapter. The chapter also deals with adequacy of and requirements for "Borrow Material Resources" along the pipeline corridor and, rather arbitrarily, includes papers on "Recreation Areas, Parks and Land Reserves" and "Archaeological Sites".

The interrelated environmental and socio-economic effects of the pipeline and the Delta gas-production facilities could also be viewed in a corridor context. Coincidence of the construction period for the two interrelated systems will result in super-imposed requirements for, and use of, barge transport, air transport, communications systems, materials, machinery, labour, services, etc. and both developments will place demands on the same communities. Moreover, the environmental effects of development of the gas-production facilities will reinforce the environmental effects of adjacent parts of the pipeline. Although a separate review of the gas-gathering and production facilities is not included in this report, further comment on its relation to the pipeline impact is contained in the socio-economic chapters.

10.2 PIPELINE-HIGHWAY INTERACTION

Introduction

The Corridor Guidelines ("Expanded Guidelines for Northern Pipelines") express concern over the spacing between a trunk pipeline and "a present or proposed highway", where the pipeline route "is parallel to and near" the highway route. In a general sense, the proposed Canadian Arctic Gas pipeline route is parallel to and near much of the Mackenzie Highway between Inuvik and Fort Simpson as well as the part of the Dempster Highway between Arctic Red River and Fort McPherson. The potential for interaction with the Dempster Highway appears to be rather limited, whereas many intersections and interactions between the pipeline and the Mackenzie Highway are apparent. Therefore this discussion centres on the Mackenzie Highway which, of course, is only partly built. This paper deals mainly with the use which the Applicant apparently will make of the highway during pipeline construction and operation, the physical effects of one facility on the other where they are close enough to interact, and the joint effect of the two transportation facilities on environment, land and people in the surrounding area.

Location data used in preparing these comments are the Proposed Pipeline Route Maps (Sect. 13.a.2.2) and Alignment Sheets and available Alignment Update Reports for the Mackenzie Highway. The Assessment Group understands that subsequent minor adjustments to both routes have reduced the number of pipeline-highway crossings.

The Applicant's proposals involve use of the Mackenzie Highway and Liard Highway for transportation of construction supplies and equipment from the railroad at Hay River and for permanent access as far north as the crossing of the Mackenzie River below Fort Simpson (Mile 643). North of this point, construction supplies and equipment will be transported by barge from Hay River and the Applicant does not intend to rely on either the Mackenzie Highway or the Dempster Highway for haulage of material from southern sources. On the other hand, as detailed in the following, there will be substantial use of the highway system for local trucking of materials from wharves or communities to the pipeline route and from point to point on the route.

Applicant's Data

"In its description of its Prime Route in Canada, the Applicant has shown that such route lies in the vicinity of the proposed Mackenzie Highway, and has been adjusted in location to be compatible with the highway" (Sect. 14.e.1.8). Moreover, a fairly detailed description of existing and proposed roads as at the date of publication is given (Sect. 14.d.N.4.10).

Details regarding the Applicant's proposed use of the Mackenzie, Dempster and Liard highways are lacking but in discussion of "Elements of Transportation" (Sect. 13.a.3.2) the Applicant points to these highways as being part of the system "which may be used in transporting materials, equipment and personnel to the construction stockpiles".

The Applicant notes that these existing and proposed highways "are suitable for project requirements but are subject to the weight and size-of-load restrictions stipulated by the governing authorities". He also recognizes that there may be other stipulations, for example, concerning use of ferries, bridges, ice-bridges and scheduling.

Rather than construct his own access roads, the Applicant registers his intention, where practic-

able, to use any of the access roads proposed by the Department of Public Works as links between the Mackenzie River and Mackenzie Highway "to the extent such access roads have been completed prior to pipeline construction".

Inspection of various maps and Alignment Sheets reveals a large number of planned or potential uses of the highways in both the construction and operational phases of the pipeline project. These are outlined in some detail in the immediately following section of this report.

The Applicant notes that, where practicable, pipeline crossings of roads and railways will be at "approximately right angles, but preferably not less than 45 degrees. Pipe bends will not be located within the length of any crossings." To determine the length and design of crossings "future widening of railway and road rights-of-way will be considered" (Sect. 8.b.1.4.2, p.4). Installation methods for such crossings are discussed in Sect. 13.a.6.5.12.

The Applicant comments on the possibility of surface icings related to the pipeline encroaching upon the highway and presenting a "hazard which can render a road impassable" (Sect. 8.b.1.3.8.1., p.49). The best solution to this problem is to avoid it: "In locations where icing occurs, the preferred solution will be to force the icings to form upslope and away from the road surface by either diverting the water at its source, or by locating the aquifer and inducing the groundwater to surface and form the icing further upstream. Adequate drainage facilities will be provided to allow the melt water from icings to dissipate in spring without causing erosion" (Sect. 8.b.1.3.8.4.1., p.64). "As there is no convenient method of pre-determining areas which will experience icing, it is planned that available techniques will be utilized when the line is in service to inhibit or eliminate icings after any areas have been identified" (Sect. 14.d.N.7.3).

Sect. 14.d.N.6.3.9, dealing with aesthetic problems, refers to maintaining an adequate separation and screening with trees of pipeline and highway. "Special care will be taken to minimize the immediate visual impact in areas of anticipated contact..." In his discussions on fire, the Applicant makes no specific reference to fires originating on highways nor to any proposed use of highways in fighting fires originating on the pipeline.

<u>Use of Highways by the Applicant</u>

From Construction Schedules (Sect. 13.a.2.3.1 and 2.3.2), the location of borrow pits and airstrips, and from other information in the Applicant's documents, the Assessment Group has inferred that the Applicant intends to, or may use, the Liard, Dempster and Mackenzie highways at the following locations (stated in pipeline mileages) during the construction, operation and maintenance of the pipeline.

Mile 90

The Applicant shows an all-weather road joining compressor station M-02 (planned for possible summer construction) to the Mackenzie Highway, thus providing access to this station via the highway from the stockpile site, airfield and regional headquarters at Inuvik and to borrow sites.

Miles 259-269

Borrow sites GM14 and 326 are located close to the proposed highway alignment but are connected to compressor station-stockpile site M-06 by a three-mile and six-and-a-half-mile temporary road, respectively. The latter parallels the proposed highway and at GM14 a one-mile temporary winter road joins the pit to the highway. It is likely

that the Applicant will use the highway, if it is built, rather than build temporary roads. Apart from the wharf at RMP 710, easiest access from Fort Good Hope to M-06, which does not have an airstrip, will be via the proposed highway.

Mile 288

The highway alignment, as shown on Alignment Sheet 1B-0200-1014, is inaccurate but, if moved to its correct location west of the pipeline, it would provide access from the wharf at RMP 685 to the pipeline right-of-way. The Applicant proposes to deliver 20 miles of pipe to compressor station M-07 during the summer of 1976, presumably via the highway.

Miles 312 and 374

If material from either borrow pit P319 or NW15 is used, the logical access from pit to pipeline appears to be via the highway.

Miles 377 and 400

The highway and an all-weather spur to the town provide access from Norman Wells, its airport and the stockpile site at RMP 565 to the pipeline right-of-way. Also, proposed pit NW4 is adjacent to the highway. The highway and a permanent access road will connect compressor station M-09 to Norman Wells. During the summer of 1977, the Applicant plans to move 21 miles of pipe from RMP 565 (Norman Wells) to M-09 via this route.

Miles 420-423

It appears that the Applicant intends to move men and materials from the airstrip at Fort Norman to compressor station M-10 via the highway and permanent access roads. In addition, much of the materials stockpiled from barges at the Fort Norman wharf, RMP 512, apparently will move along some part of the highway to their destination on the pipeline, in particular the 14 miles of pipe scheduled for stockpiling at M-10 during the summer of 1977. It is not clear what traffic the Applicant will have on the highway proceeding northward from Fort Norman.

Mile 486

It is inferred that the permanent road joining the compressor station and airstrip is intended to connect with the highway and thus provide access from the wharf at RMP 435 to M-11 at Mile 490. All material off-loaded from barges at RMP 435 apparently will be trucked to the pipeline via this route.

Miles 536-583

It appears that the Applicant intends to move materials and men from the airstrip at Wrigley to compressor sites M-12 and M-13 via the highway and permanent access roads. A permanent road from RMP 334 to the highway on the north side of River Between Two Mountains and another from the highway to the compressor site on the south side of the river (Alignment Sheet 1B-0200-1039) suggest that the 40 miles of pipe to be stockpiled at M-13 in the summer of 1976 will be transported from the wharf via the highway and the highway bridge. Borrow material from pits P146, W5 and P152 may be moved by this highway.

Miles 620-645

A permanent road will connect M-14 to the Mackenzie Highway. It appears that considerable pipeline traffic will move along the highway both north and south from this station, and that the 20 miles of pipe scheduled for delivery from the wharf at RMP 225 to M-14 (Mile 620) in the summer of 1976 will be transported via the highway.

Mile 645

South of the Mackenzie River crossing the Applicant proposes to use the Mackenzie Highway both for local traffic of the type discussed above and for transfer of equipment and material from the railhead at Hay River. In the winter of 1976-77, the Applicant intends to haul 21 miles of pipe via the highway directly from Hay River/Enterprise. Miles 357-382 of the highway, which include a ferry/ice-bridge across the Mackenzie River, will provide an important communications link with Fort Simpson and will probably be used extensively.

Mile 670

A permanent road connecting compressor site M-15 with the highway (Route Map 1B-0211-1005) indicates that the Applicant intends to use the highway as a communications link between Fort Simpson and the pipeline.

Mile 705

Borrow pits GM22 and GM98 are both situated on the Liard Highway and material from either would be moved by road. Seven miles east of the pipeline the Liard and Mackenzie highways meet, providing another link with Fort Simpson. The 59 miles of pipe scheduled for delivery at M-16 during the summer and winter of 1977-78 will be moved from Hay River via the Mackenzie and Liard highways and an all-weather road.

Prudhoe Bay Lateral, Miles 430-460

Use of the Dempster Highway between Arctic Red River and Fort McPherson is not clear from the Applicant's proposals. A two-mile permanent road linking the pipeline and highway at Mile 436 will provide access from the pipeline to the highway and thus to Fort McPherson. The wharf-stockpile site/borrow-pit complex on the east side of the Mackenzie River is connected by a permanent road to the Dempster Highway at a point where the highway and ferry/ice-bridge crossing at Arctic Red River provide an important communications link between Inuvik and Fort McPherson.

Concerns

Concerns arising from interaction between the proposed gas pipeline and the Mackenzie Highway (and other roads) vary with the distance between them as well as the particular nature of the area through which they pass. In the following, "close spacing" refers to places where the two facilities are one mile or less apart and "very close spacing" means one-quarter mile or less. Some of the concerns involve effects of one facility on the other and some involve the effect of the two facilities on their surroundings. Regarding the latter, as indicated further for the particular concerns discussed below, close or very close spacing will concentrate adverse impacts and possibly lead to a reinforced combined effect; wider spacing may avoid combined effects and disperse the impacts but would involve a greater total area.

Failures and Contingencies

Both construction and operation of these transportation facilities may, on occasion, give rise to failures and contingencies, such as landslides, erosion, pipeline rupture, fire and culvert or bridge problems. Where the pipeline and highway are closely spaced, a failure caused by one facility can adversely affect the other. Moreover, very close spacing can lead to an increase in the number and magnitude of failures or may cause different kinds of failures.

Assigning of legal responsibility for any disaster or for repair and rehabilitation may prove diffi-

cult and is compounded by the fact that the pipeline will be privately owned and operated whereas the highway is controlled by the Crown.

Terrain and Engineering Concerns

Both the construction and operation phases of the pipeline may involve various effects of the pipeline on the highway and vice versa where the two facilities are close together. In general, adverse interactions are expected to be greater if the pipeline is located just upslope from the highway rather than well upslope or downslope.

Operation of a chilled gas pipeline or the highway may initiate surface icings. Icings generated by the upslope facility may encroach on or affect the downslope facility. Although possible control measures are outlined by the Applicant, it would appear that a commonly easier solution is to route the facilities so that any icings that may develop from one do not encroach on the other. In terms of pipeline design, this would involve prediction of areas where such trouble could occur (*see* topics "Springs and Icings" and "River Crossings"). In some situations, surface icings or a frost bulb could lead to the ponding of water on the ground surface. Where pipeline and highway are closely spaced, this may result in sapping or failure of the highway berm. As above, a commonly easy solution is avoidance.

Passage of overland drainage across the pipeline is to be achieved by "mound breaks" (Sect. 8.b.1.3.8.4.1) and across the highway by culverts. Where pipeline and highway are close together, the probability of concentrated flow increases. Initially this would develop in the zone between the two facilities, but could subsequently extend both up- and downslope. The potential danger in such a situation is that erosion or thermal degradation may occur and thus threaten the stability of either facility. In view of the above, special site-specific design of cross-drainage structures for both facilities may be needed in some areas of close or very close spacing.

Waterbodies and Fish Concerns

Construction or operation and maintenance of both the pipeline and highway may cause changes in water quality (sedimentation, toxic chemicals), in water quantity (increased run-off) and in water regime (flood-peak timing, stream icings, low flows, water levels in lakes). Concerns over waterbodies and fish identified in this section occur at those places where the pipeline and highway together may increase the adverse effects on the water, fish and other aquatic organisms.

The potential concerns fall into two distinct categories depending upon the pipeline phase (whether construction or operation) with which they are associated. It is unlikely that both facilities will be constructed simultaneously but if construction of the pipeline is immediately at, or a short distance upstream from, an existing highway crossing of a river, for example, passage of water through a highway culvert could be affected. During the operations phase, close juxtaposition of pipeline and highway could lead to additive increases in the levels of silt or toxic materials in the water. The two facilities do not necessarily have to cross a waterbody to present a potential problem: such may occur, for example, where both facilities are aligned close together on a hillside and drain into a waterbody. In assessing potential adverse effects on waterbodies, it should be noted that close spacing may offer some advantage because only a few waterbodies would be affected, whereas a larger number might be involved if the facilities were far apart.

Recreation sites and visual aesthetics are important to travellers on the highway. Location of the pipeline relative to the highway will affect vistas from viewpoints along the road itself. Secondly, where the pipeline and highway are close or even moderately close, there are particular concerns about the protection of potential recreation sites or their access routes from interference by the pipeline or its facilities.

In a broader context, very substantial visual effects will result from the existence of a highway and of a pipeline (*see* topic "Aesthetics"). As mentioned above, the concerns and importance of the visual effects and the appropriate approach in attempting to reduce adverse effects will differ from place to place. In some situations, close spacing of the facilities confining their impact to a narrow zone could decrease the over-all visual impact and serve to reduce wilderness degradation. In other situations, however, a wider separation might be more acceptable.

Finally, in sections where pipeline and highway are very close together, the Applicant proposes to leave a narrow strip of trees standing between the two rights-of-way. There is concern that such strips, some of which are less than 300-ft wide, may be susceptible to blowdown.

Ice-Fog Concerns

In very cold weather ice fog, which occurs as a result of combustion, will undoubtedly be generated by compressor stations. Several of the Applicant's proposed compressor stations are fairly close to, and upslope from, the highway and some moderate increase of ice-fog frequency over adjacent sections of the highway is possible. Of course, ice fog can also be caused by exhaust from vehicles on the highway.

Geographic Locations

The Assessment Group has identified 17 areas where the pipeline and Mackenzie Highway are less than one mile apart. Some of these areas involve a single length of close spacing or a single pipeline-highway crossing; others include several. In total, 220 miles and about 20 crossings are involved. As indicated in the foregoing, this close spacing may have advantages in some places and disadvantages in others. Descriptions of potential pipeline-highway interactions in two of these areas are presented below to illustrate the kinds of concerns involved. Review of interactions in other areas of close spacing could serve to identify potential problem locations.

Gibson Pass Area (Miles 331-335). The highway and proposed pipeline routes are closely-to-very-closely spaced through Gibson Pass and thence along the foot of Brokenoff Mountain. The close spacing in the pass is dictated by topography and below the mountain it serves to avoid highly sensitive permafrost. Both areas are of high interest in terms of visual aesthetics and have considerable recreational potential. The presence of springs and possible development of icings with associated drainage, erosion and stability problems could complicate the design of both facilities. The local terrain will leave little opportunity for minor relocations to avoid foundation and drainage problems. Close spacing of the two facilities is expected to result in reinforcement of adverse visual effects. The Assessment Group considers that adjustments in design and construction methods and strict control over construction machinery would serve to reduce adverse visual impacts substantially, but could only partly offset the combined aesthetic disturbance caused by these two closely spaced facilities.

Willowlake River Area (Miles 597-602). At and near

the crossing of this river the highway and proposed pipeline routes are closely-to-very-closely spaced in an area where potential route locations are topographically restricted and where construction engineering is complicated by river-bank instability, springs and potential icings. This is also an area of present and traditional occupancy by native people and of particular importance for fishing; it includes archaeological and burial sites and an historic site; and is of recreational and aesthetic importance. The latter relate to potential tourist activities at the river, potential recreation areas associated with thermal springs, and the visual effect of development as seen from both the highway and Mackenzie River. The highway route has been adjusted to reduce adverse effects relating to the above, but placing the pipeline close to it raises substantial additional concerns. The Assessment Group considers that this close-and-very-close spacing is unfortunate and special attention to design, construction and rehabilitation will be needed in some sections if adverse impacts are to be kept at a low level.

Highlights

1. This paper deals mainly with the use which the Applicant apparently proposes to make of the Mackenzie Highway during pipeline construction and operation, the physical effects of one facility on the other where they are close enough to interact, and the joint effect of the two transportation facilities on environment, land and people in the surrounding area.

2. Although the Applicant does not intend to rely on the highway as a major haulage system north of the Fort Simpson area, he will make specific use of it for local trucking of materials from wharves or communities to the pipeline route and from point to point on the right-of-way. This paper includes an inventory of some of the probable locations and kinds of use.

3. Close spacing of pipeline and highway may increase the potential for various adverse effects as noted in the following.

> A failure or contingency at one facility could adversely affect the other and interactions between the two could increase the incidence of such problems.
>
> In terms of terrain and engineering, close spacing could generate interactions and increased problems relating to icings and cross drainage.
>
> Close spacing across or close to waterbodies may cause additive increases in the levels of silt or toxic materials in the water, or lead to adverse effects on the downstream facility.
>
> Close spacing could result in greater changes in drainage and wetland habitat in valleys and other wetland areas used by various wildlife, and may retard opportunity of movement along valleys by animals, such as moose.

Some of the adverse effects of close spacing listed above may be accompanied by beneficial effects resulting from the reduction in total land use that would be involved if there were separate impacts in separate places. The relative importance of such adverse effects and benefits can only be resolved on a site-by-site basis.

4. The effect of close spacing of pipeline and highway on traditional activities by native people can only be identified on a site-by-site basis. Close spacing might result in avoidance of one native-use area or a major impact upon another.

5. One of the benefits of close spacing of pipe-

line and highway is a decrease in potential environmental damage resulting from increased ease of access to the pipeline right-of-way, facilities and borrow pits.

6. In areas of close spacing, the pipeline could have an adverse effect on views from the highway and on potential recreation sites along the highway. In some situations, close spacing of the two facilities, confining their impact to a narrow zone, could decrease the over-all visual impact and serve to reduce wilderness degradation. In others, however, a wider separation might be more acceptable.

7. The pipeline and highway are less than one mile apart in 17 areas totalling some 220 pipeline miles. Some of these involve sections with potential for substantial impact. Examples are cited in the Gibson Pass and Willowlake River areas.

10.3 BORROW MATERIAL RESOURCES

Introduction

Most engineering developments require the use of construction materials derived from local sources, both rock and soil. Construction of the pipeline will generate a large demand for such materials although somewhat less, mile for mile, than the Mackenzie Highway. The principal additional requirements for such materials that are presently predictable relate to community use, the Mackenzie and Dempster Highways, petroleum exploration and gas production in the Mackenzie Delta area. Further requirements in the future may include looping of the gas pipeline, an oil pipeline, additional roads and airfields, hydro-electric development, port development and possibly a railroad.

Government, industry and local people have all expressed concern as to the adequacy of the supply of these construction materials in the narrow corridor under consideration and the Expanded Guidelines for Northern Pipelines specifically refer to the need for information in this regard. The good-grade materials are not evenly distributed through the corridor: in some areas there is no scarcity and in others a shortage. In areas of shortage, good-grade materials may have to be reserved to meet selected requirements; for some purposes it may be necessary to use poorer grades, to process materials to improve grade, or to haul from a substantial distance. To aid in assessing shortages and to identify granular resources that should be reserved for future needs, the Government of Canada has embarked on an inventory of granular resources for the Mackenzie Valley.

Construction materials range from coarse rip-rap through various specialized needs for gravel, sand, crushed stone or clay, to general borrow or fill materials of a less specific character. Requirements for the latter can be met from various kinds of natural sources and the material chosen will depend on cost of extraction, cost of transportation, ease of access and the environmental acceptability of the borrow operation. The quality of granular materials is determined by the proportions of fine, medium and coarse particles. The best quality, a well-graded, medium-grained gravel, is used for concrete aggregate. Should this particular material be scarce, such an aggregate may be processed by quarrying and crushing good grade bedrock, but this results in increased costs.

In ordinary situations, where there is no permafrost, the unconsolidated or "soil" materials are the cheapest borrow sources (these include sand, gravel, clay and glacial till); bedrock sources requiring costly blasting and crushing are less widely used. In permafrost, however, the situation is different. Many soil materials are ice-rich and may have to be blasted as if they were bedrock. In the summer, melting ice may soften the soil and render it extremely difficult to excavate using standard construction equipment. Materials placed as fill or set aside as spoil during the winter may soften during the summer (as a result of thawing) and create problems of flow or subsidence. Thus, permafrost soil materials, which may be ice-rich, are generally less useful as borrow sources than non-permafrost soil materials which do not contain ice. The ice content increases from south to north and, in general, is higher in poorer-grade borrow materials than in gravel. In contrast, bedrock in permafrost commonly contains very little ice. In view of this and the above arguments, even soft or shaley bedrock, which is relatively ice-free and can be ripped with a ripper instead of requiring drilling and blasting, may prove to be an

important source of general fill, despite the fact that it is normally regarded as a low-grade material elsewhere.

Moreover, pit operation in ice-rich permafrost soils may have serious side effects. For example, removal of the insulation layer can result in thawing and consequent slumping of the materials left in the pit. Also, access roads into the pits must be constructed so as not to damage the insulating layer of organic material overlying frozen soil. These factors and environmental concerns may well prescribe the selection of pits and mode and season of operation (*see* topic "Environmental Effects of Borrow Operations").

Applicant's and Other Data

Although the Applicant has provided a substantial amount of information concerning his borrow requirements and proposed borrow sources, certain gaps in this information have hampered the assessment. These have been identified by the Assessment Group in the requests for Supplementary Information. In the meantime, the Group has proceeded with its review on the basis of certain assumptions, as outlined below.

The Applicant proposes 126 borrow pit areas and alternates for the entire Canadian section of the pipeline north of 60° Lat., a distance of some 1,150 miles. This averages one pit per 9 miles of pipe. However, 17 of these pits are alternates and there are a few very long distances for which no pits are designated. The Group must, therefore, assume that further pits will be allocated at a future date.

The Applicant estimates that his project will require 30 million cu yd of borrow material (Sect. 4.d.N.2.2.1, p.8) and the Land-Use Tables accompanying the Proposed Pipeline Route Maps (Sect. 13.a.2.2) indicate tentative amounts required at the individual sites of the larger facility complexes (that is, compressor stations, stockpile sites, wharves, etc.). Most of the borrow areas are obviously located with this purpose in mind. The amounts needed for other facets of pipeline construction, such as helipads, river weights and miscellaneous backfill, are much smaller, although specific figures are not given in the Application. Thus, the principal requirement for borrow is for use at facility sites. The Applicant's statements regarding fill requirements are of a very general nature and quantities to be excavated from individual pits are not specified. The Group has allotted certain amounts to certain pits using available data (*see* "Appendix: Environmental Effects of Borrow Operations", tables 1-4) and has arrived at the conclusion that 37 pits (or their alternates) will be large; that is, they will each provide more than 100,000 cu yd.

The Applicant makes no specific statements concerning the nature and grade of the material he will require. However, from the data available, the Assessment Group has assumed that most of the material needed will be general fill used to build up the stockpile sites, airfields, roads, wharf pads, etc. and that smaller quantities of better quality material will be needed to surface airfields, roads and other facilities and for concrete aggregate. The Group has, therefore, inferred that the Applicant will use large volumes of low-grade material and smaller volumes of good-grade material.

The Applicant has relied heavily on the Government's granular resources surveys in locating his borrow sources; for many pits, the location and numbering codes are those established on the government reports. The Applicant does not comment on potential conflicts in use of granular materials or on other developments that will

require such materials.

Concerns

Comments on the resource considerations involved in each borrow pit proposed by the Applicant and along all parts of his route except the Yukon Coastal Plain are contained in the Appendix at the end of this paper. In this section, specific points of concern are extracted from the Appendix, focussing on communities, the Mackenzie Highway, industrial uses and general supply shortages.

Community Requirements

Borrow pit locations proposed by the Applicant involve sources in present use or of potential future importance in Inuvik, Fort Good Hope, and Norman Wells. Additional overlap with community supplies of borrow materials is possibly involved at Fort Norman and Fort McPherson. At present state of knowledge, it is not possible to comment on any possible conflict between the Applicant's proposed use of borrow sources and the borrow requirements of new communities that may develop in the future.

At Inuvik, the Applicant (Sect. 13.a.2.2, Drawing No. 1A-0211-1001) identifies a borrow source, GM137, near the town, presumably to meet his requirements for 360,000 cu yd of fill at the stockpile site and in the town. The limited quantity of gravel and sand remaining at this location is needed for general purposes in the community; hence, the Assessment Group assumes that a different source will be selected for building the stockpile site.

At Fort Good Hope, the Applicant proposes to develop a large borrow pit adjacent to the settlement to supply material for the wharf, stockpile site, extension of the airfield, roads and other purposes. There are large supplies of granular materials in the vicinity of this community but until specific information is provided by the Applicant regarding the location and size of his pit, it will not be known whether the proposal is in conflict with community development plans or needs to reserve local, high-grade gravel sources.

At Norman Wells, borrow materials are trucked from one of several sources within a few miles radius of the community. The principal pit serving the community is also identified by the Applicant as the source of borrow material to meet his requirements for wharf, stockpile site and other purposes. Moreover, the pit is proposed for use in construction of the Mackenzie Highway. This source (NW4) contains large reserves of limestone and shaley bedrock materials within the Ramparts and Canol Formations, which are expected to be adequate to meet all the proposed uses. However, as the pit is expanded, extraction of good-grade materials may become more costly. The Applicant's alternate borrow source near Norman Wells is at Bosworth Creek (NW15) in an area of gravel. The Assessment Group has indicated elsewhere that development of this source potentially would conflict with recreational values. However, there are several other borrow sources in the general area (for example, NW8, 9 and 10X). Thus, in terms of supply there need not be any conflict with the community.

At Fort Norman and Fort McPherson the Applicant proposes to build stockpile sites requiring, respectively, 242,000 and 145,000 cu yd of borrow material but does not designate the borrow sources. As good-quality granular materials are in short supply at both communities, the location of pipeline borrow pits is of some concern.

ildlife Concerns

ipeline-highway interactions occur south of Inuvik nly; thus, some of the wildlife concerns registerd elsewhere in this report do not apply.

he chief concern over close spacing of the two failities centres on valley and wetland areas. It s possible that in some places greater changes in rainage and thus in wetland habitat would be created by close spacing of the two facilities than by he individual facilities. A valley crossing by ither the highway or the pipeline may retard or hange the pattern of movement of animals such as oose. Close spacing of the two facilities may inrease the importance of this effect. On the other and, placing the two facilities close together may educe potential effects on certain wildlife (e.g. aptors) as less of the landscape would be involved n transportation development.

raditional Activities

n determining the combined impact of pipeline and ighway on traditional activities, three factors ave to be considered: the geographic location of he facilities and traditional use areas; the relaive location of the two facilities; and the added ffect of close spacing. Therefore, the advantages, isadvantages and concerns can only be identified n a site-by-site basis. In one location, for exmple, close spacing of the two facilities might esult in by-passing completely of a native-use rea; in another location it might mean both traersing a traditional-use area and placing maximum npact upon it.

ccess

e highway will markedly increase public access d thus permit greater exploitation of wildlife d fish resources. The pipeline will have a similar, but smaller, effect. However, generalizations cannot be made on the combined effect of the two of them, whether close together or far apart. Potential impact must be assessed on a site-by-site basis.

On the other hand, one of the benefits of close spacing of pipeline and highway is a decrease in potential environmental damage resulting from increased ease of access to the pipeline right-of-way, facilities and borrow pits. Thus, in areas of close spacing, temporary and permanent access roads are short, use of the highway for movement of construction material across valleys can reduce the need for cut grading for vehicle operation on steep slopes, and less overland vehicle movement is needed for pipeline repair.

Conflict over Construction Materials

Local shortages of high-quality granular materials, or even depletion of a source, could result from use of borrow materials by highway and pipeline and concerns in this regard could be reinforced where the two facilities draw upon the same or nearby sources. The topic "Borrow Material Resources" discusses this subject and concludes: "It is unlikely that there will be any important conflicts between borrow-resource use by the pipeline and by the Mackenzie Highway." Where the two facilities can use the same pits, the number of separate borrow operations will be reduced and the aesthetic impact on the environment will be lessened.

Aesthetics/Recreation Concerns

Four aesthetics and/or recreation concerns are considered in this section; further discussion of this general subject is contained in the topic "Recreation Areas, Parks and Land Reserves".

Mackenzie Highway

It is unlikely that there will be any important conflicts between borrow resource use by the pipeline and by the Mackenzie Highway. Only a small proportion of the borrow sources proposed by the Applicant are also proposed for development in connection with the Highway. Moreover, it is expected that much of the Highway will be built before pipeline construction begins and, in a very few places, there is a chance that Highway construction may deplete sources that the Applicant proposes to use.

Industrial Development

The principal industrial use of granular materials in areas along the pipeline route is expected to take place on Richards Island. Here petroleum exploration is placing a substantial drain on the granular resources, and construction of gas gathering and production facilities will require much more material. In comparison, direct use of granular materials for the pipeline is modest and will not appreciably reduce the local supply of borrow materials available for gas production facilities and other industrial uses. This matter is developed further in the section of the Appendix that deals with pipeline mileage 00-90.

General Supply of Granular Materials

Also of concern is the cumulative effect of use of borrow materials by pipeline, Highway and other large developments on the general supply of granular resources within the transportation corridor. From available data it is apparent that there will be local shortages, particularly of high-grade materials, and that prudent use of available resources (for example, reservation of high-grade materials for jobs needing them) is of importance. Based upon the Government's granular materials surveys, shortages are most likely to occur in the following areas:

- mile 124-210, south and east of Travaillant Lake
- mile 297-309, southward from Fort Good Hope
- mile 357-376, north from Norman Wells
- mile 422-455, south from Great Bear River
- mile 507-533, north of Wrigley
- mile 348-400 on the Prudhoe Bay Coastal route west of Mackenzie Delta.

Highlights

1. The Applicant proposes to use about 30 million cu yd of borrow materials of various grades from about 130 sources in the northern Territories. Some sources are in areas where general shortages of good-grade granular materials have been identified from the Government's granular materials inventory. Nonetheless, the Assessment Group has not recognized major supply conflicts or critical depletion of resources arising from the Applicant's proposals.

2. Review of the resource use and resource conservation implications of each borrow source proposed by the Applicant is limited at present by lack of specific information regarding the grades and specifications of the materials required, the quantities of each grade (including spoil material) to be extracted from each pit, and the approximate size and depth of the pit. A definitive assessment of the resource-use aspect of individual pits based upon such specific information would be appropriate at a later stage in the approvals process, perhaps in connection with application for quarry permits.

3. A few of the borrow pits proposed by the Applicant draw upon sources that are presently used for communities, that potentially may be needed for community use, or that lie within community lands. Specific sites have been identified at Inuvik, Fort Good Hope and Norman Wells.

4. It is unlikely that there will be any important conflicts between borrow resource use by the pipeline and by the Mackenzie Highway. Similarly, no important conflicts between pipeline use of borrow resources and use of borrow materials for other industrial development (particularly petroleum industry) have been identified, although the pipeline requirements on Richards Island add an extra increment to the heavy industrial drain on granular resources in this area.

APPENDIX: BORROW MATERIAL RESOURCES
COMMENTARY ON INDIVIDUAL PITS

Introduction

This Appendix provides information on each of the Applicant's proposed borrow sources and comments on their relationship to requirements for the Mackenzie Highway and the communities along the route.

The descriptions of the materials in the borrow areas proposed by the Applicant were obtained from various reports and maps prepared by the Geological Survey of Canada (GSC) and by granular materials consultants to the Department of Indian Affairs and Northern Development (DIAND). In general the quantities of material available were taken from the consultants' reports. It should be noted that some of the Applicant's proposed borrow pit areas are shown as adjacent to but not exactly on a granular deposit as indicated on the GSC or DIAND maps. Where the discrepancy is small, the Assessment Group has proceeded on the assumption that the pit is intended to coincide with the granular deposit. Sites where the discrepancy is larger have been indicated in the tables by an asterisk.

Prime Route

Richards Island to Inuvik, Miles 00-90

For these miles, the following nine pits are proposed:

Pit No.	Mileage	Distance from R.O.W.[1]	Material
GM135	00	5 mi southwest	Sand
3	18.5	1 mi east	Gravel and sand
GM134	23	1 mi east	Sand and gravel
10	26	1 mi east	Gravel and sand
GM133	39	16 mi east	Glaciofluvial gravel
GM132	39	¾ mi west	Glaciofluvial gravel
GM136	43	3 mi east	Glaciofluvial sand and gravel
GM4	57	east side	Till veneer over bedrock
GM5	66	½ mi west	Gravel

[1]R.O.W.—Right-of-way.

The most important granular deposit along this section of the pipeline route is located immediately south of Yaya Lake on Richards Island, where about 8 million cu yd of good quality material occurs in an east-west trending esker, the east end of which is about 4 miles west of proposed borrow pit area GM134. During the past two to three years oil companies have developed pits in this deposit to obtain material for use during their exploration activities. There are no precise data as to quantities excavated up to the present, although it has been estimated that Shell removed about 30,000 cu yd during the winters of 1972-73 and 1973-74. Consultants to DIAND have reported that much of the material is of a sufficiently high quality to be suitable for concrete aggregate. Consequently, the Applicant may make a demand upon it, especially as numerous access roads into the deposit already exist.

Proposed borrow pit GM134 lies about one mile west of mile 23 on the pipeline route. In this area Gulf has opened a small pit which is located on an extensive deposit of granular material containing an estimated 10 million cu yd of poorer quality, silty-gravelly sand. The Applicant could undoubtedly satisfy his general fill requirements by using this material and also, depending upon the quantity needed, obtain concrete

aggregate by processing it. During the past few months DIAND has become concerned over the increasing demand for granular material from the esker west of area GM134 and is considering stricter control over its use. For general fill requirements, there is no apparent reason, other than increased haulage costs, why the poorer quality material from the more extensive deposit at GM134 could not be used by all industry.

The Mackenzie Highway, which presently terminates at Inuvik, will not require materials from any of the borrow sources in the above list. However, the route for future extension of the Highway from Inuvik to Tuktoyaktuk crosses the pipeline route at approximately mile 63, equidistant from pits GM4 and GM5, and near the north end of Parsons Lake would pass within one mile of pit GM133.

Inuvik to Junction with Prudhoe Bay route, Miles 90-143.9

The following five pits are proposed for this section of the route:

Pit No.	Mileage	Distance from R.O.W.	Material
GM137	91	13 mi northwest in Inuvik	Glaciofluvial gravelly, silty sand
GM138	91	4 mi east	Glaciofluvial silty sand
GM39	91	½ mi east	Till veneer over bedrock
GM78	120	west side	Till overlying shale
GM140	129	8½ mi east	Glaciofluvial sand and gravel

In addition, the Applicant has indicated he may require material from a DPW pit located between the Mackenzie Highway and Campbell Lake, which was opened during construction of the section of the Highway extending south from Inuvik.

The Applicant proposes to build a 1.5-mile permanent road west from compressor station M-02 at mile 95 to the Dempster Highway. Pipeline materials unloaded at the proposed wharf at Inuvik could be hauled to the pipeline route via this road as well as borrow materials from the DPW quarry mentioned above and from GM39.

A pit is presently being operated in area GM137, approximately 1 mile south of Inuvik, and the material, gravelly, silty sand, is used locally for general fill. Some 250,000 cu yd remain at this site. However, the Applicant's requirements in this area, for a stockpile site and Operating and Maintenance Division and District Headquarters in the town, total some 360,000 cu yd.

The reason for the Applicant to develop pit GM138 is not apparent. The silty sand there would not provide better general fill material than the material from pit GM39, and a 4-mile access road would be needed.

It appears that in only two of the Applicant's proposed borrow pit areas will there be a possible demand by the Highway for construction material. One of these, GM78, is located in an extensive area of shale overlaid by a thin veneer of till. Unlimited quantities of material suitable for general fill for both pipeline and Highway are available in this area. The second area, pit GM39, is located near the north end of Campbell Lake. Here both facilities skirt the edge of the lake, and the proposed route of the pipeline is only a few hundred feet east of the newly constructed Mackenzie Highway. Material in this area consists of bedrock covered with a thin veneer of till. With the possible exception of material for maintenance purposes, it is doubtful if the Highway will have any demand for material from this pit. It is believed there is sufficient material in this proposed pit to meet the requirements of the pipeline for general fill.

In proposed borrow area GM140 only a small pit

would be opened on an esker to supply limited quantities of sand and gravel for a helicopter landing pad, the base of a communications tower and concrete aggregate. There would be no demand by the Highway for material from this proposed pit area and there will be much more material available than will be required.

Junction with Prudhoe Bay route to Fort Good Hope, Miles 126.5-285

Pit No.	Mile-age	Distance from R.O.W.	Material
GM8a	126.5	1 mi east	Till
256	130	north side	Glaciofluvial silt
GM96	142.5	north side	Glaciofluvial sand and gravel
GM116	143	3 mi south	Shale partly covered by clay
None	176	1 mi west	Till
GM10	177	2 mi west	Glaciofluvial gravelly sand
300	180.5	1 mi east Alt. to GM10	Glaciofluvial silty sand
GM117	199	3 mi east	Shale (?) with veneer of till
303	203	1½ mi east	Shale (?)
306	211.7	¼ mi east	Glaciofluvial gravelly sand
308	218.5	¼ mi west	Glaciofluvial sand and gravel
319	231	¼ mi west	Clayey silt
321	251	¼ mi west	Glaciofluvial gravelly silt
GM14	259	¾ mi west	Limestone (?)
326*	269	¾ mi west Alt. to GM14	Alluvial gravel (?)
328	276	½ mi west	Till (?)

*Location as plotted does not coincide with probable source.

At the junction of the main and coastal routes there is a shortage of better grade granular materials. Consultants to DIAND have described the materials in the area as "variable from gravelly silt and sand to silt" and further state that they are "Generally of poor quality and unsuitable for construction purposes". Bedrock underlying the area consists of shale. Proposed borrow pit area GM8a, located about one mile north of the junction, consists of till, according to GSC surficial geology maps. In summary, there are large quantities of fair to poor fill material available for construction but no granular materials suitable for surfacing pads, concrete aggregate or rip-rap have yet been identified. This shortage may cause difficulties in surfacing the 6,000-foot airfield and the station pad at station M-03.. These surfacing materials, as well as the normal requirements for small quantities of fill, will probably have to be taken from proposed pit 256. This borrow area is located in till close to the north end of a low ridge, which, according to DIAND consultants, consists of glaciofluvial silt. There will be no demand from the Highway for materials from this region.

An estimated 2.5 million cu yd of material exists at proposed pit GM96, which is located on the east edge of an extensive area of good quality glaciofluvial sand and gravel. The high quality of the resource makes it an important deposit. Consequently there will be a demand on it from both the pipeline, which crosses its southern half, and the Highway, which skirts its northern tip. Providing demands are limited to actual needs for good quality material, there should be sufficient material to satisfy the requirements of both facilities.

Proposed borrow pit area GM116 is situated near the top of a high hill on which the Applicant proposes to construct a communications tower. The south side of the hill consists of a rock scarp in which shale is exposed. Any quarry development in the shale would be small as only the helicopter pad and base of the tower require material. There would be no demand by the

Highway for material from this pit.

In the Thunder River area the Applicant proposes several facilities, including some 7 miles of access roads, and consequently will require substantial quantities of granular materials. To meet these requirements three borrow pit areas are proposed: GM10, situated in an area of good quality, glaciofluvial gravelly sand; 300 (alternate) in an area of silty sand, and an unnumbered pit in an area of till. From the point of view of gravel resource considerations only, it would appear appropriate for the Applicant to be permitted to develop GM10 but that the material in pit 300 be reserved for Highway use. The proposed Highway route passes directly across the silty sand deposit of area 300, which should provide suitable general fill. The Highway would not need material from GM10 as an extensive deposit of fair quality sand occurs along the sides of Thunder River about 4 miles north of the Highway crossing.

The Applicant proposes to construct access roads across thermally sensitive terrain to develop pits GM117 and 303 which are located close to the toe of the east wall of the Mackenzie River valley where exposures of shale occur. Large quantities of general fill material are available here. However, about 4 miles north, where the proposed routes of the pipeline and Highway cross one another, at least three extensive outcrop areas of shale occur ½ mile to the east. It is believed that a more accessible quarry could be developed in one of these areas.

Proposed borrow pit area 306 is located on the north side of a relatively small area of good quality glaciofluvial gravelly sand which is crossed by the pipeline route. The estimated quantity available, 175,000 cu yd, is sufficient to meet pipeline demands in this area. It is doubtful if the Highway will require any of this material.

There is an estimated 42 million cu yd in proposed source 308, which is located on the east side of an extensive area of fair to good quality glaciofluvial sand and gravel. This is considerably more than will be required to meet the combined pipeline and Highway demands.

Potential borrow area 319 is located close to the pipeline route on the west side of a glaciofluvial deposit comprising mainly clayey silt. The Applicant would use small quantities for general fill, and the Highway would not make any demands.

Proposed borrow area 321 at the north end of an esker, which parallels the east side of Tieda River, is situated in material described by DIAND consultants as gravelly silt. The estimated 50,000 cu yd available is not sufficient to meet combined Highway and pipeline demands. A possible alternate source for the Highway is a deposit of similar material about ¼ mile upstream of its crossing of the Tieda River.

Material from proposed pit area GM14, located close to unlimited amounts of fair to good quality limestone, is available in sufficient quantities to satisfy any demands made upon it by pipeline and Highway, both of which cross it. The Applicant proposes to transport the material over a 3-mile temporary road to a compressor station and communications tower on the right-of-way and thence along a 4-mile permanent road to a wharf on the Mackenzie River. The Highway would use the material as rock fill, riprap, concrete aggregate and road surfacing, and may also stockpile for maintenance purposes.

Proposed borrow area 326, apparently situated in the flood plain of the Loon River, would more sensibly be located in the estimated 1.9 million

cu yd of good quality glaciofluvial gravel and sand which occur in terraces along the sides of the river immediately downstream from the pipeline crossing. In the Application, pit 326 is classed as an alternate to GM14. As there is a shortage of good granular material in the area, the Highway, which crosses the river about one mile upstream, will make substantial demands on this deposit. As an alternative, the Applicant could avoid using this material by hauling from the quarry in the limestone exposed in pit GM14.

Borrow pit area 328, about 9 miles north of Fort Good Hope, is apparently in or close to the valley of a small stream. According to GSC maps, material in the area consists of till, although the Applicant may be hoping to obtain some alluvial gravel from the valley of the stream. The Highway passes between the pipeline right-of-way and the proposed pit area and will make demands on the material if it is suitable for road construction. As the Applicant has no proposed utilities in the area, requirements would probably be relatively small.

Fort Good Hope to Norman Wells, Miles 285-373

Pit No.	Mileage	Distance from R.O.W.	Material
FGH3	286	1½ mi west	Glaciofluvial sandy gravel
FGH2	287.5	1¾ mi west	Glaciofluvial gravel
FGH7*	294.3	east side	Till (?)
P315	303	½ mi east	Till (?)
P319	312.5	½ mi east	Limestone
374*	342	1 mi east	Middle Devonian limestone and shale (?)
374a	347.5	1 mi east	Limestone and dolomite, considerable talus
P291	357.5	1¼ mi west Alt. to P289	Glaciolacustrine silty sand
P289	357	¾ mi west	Glaciofluvial gravel and sand
413	367.5	½ mi west	Glaciofluvial sand and gravel

*Location as plotted does not coincide with probable source

Pits FGH3 and FGH2, as noted above, lie within the boundaries of the Ford Good Hope community. However, the quantity of good material is large, there being an estimated 7 million and 30 million cu yd respectively. Also, there is an extremely large volume of fair quality granular material about 10 miles upstream on either side of the Hare Indian River, which could, if necessary, be barged down to the construction area. It is believed that the large quantities of granular materials in the whole area are more than sufficient to meet the combined requirements of pipeline, Highway and community in the foreseeable future.

FGH7, which is within the boundaries of the community of Fort Good Hope but some distance from the settlement, is plotted on a thermally sensitive till plain about one mile south of a long narrow esker containing an estimated 100,000 cu yd of poor quality silty sand suitable only as marginal fill. It is assumed that the Applicant intends to use this esker deposit as his source. The estimated combined demand of pipeline and Highway in the Fort Good Hope area is about 500,000 cu yd, which is considerably more than the quantity available in this esker. Clearly FGH7 cannot serve adequately as a substitute for FGH2 or FGH3 if restrictions are placed on their use.

It would appear the Applicant intended borrow pit P315 to be located on an east-west trending, discontinuous series of esker-like ridges containing

an estimated 600,000 cu yd of good quality gravel instead of about one mile north on the till plain, as indicated on his maps. These ridges have been classified by DIAND consultants as environmentally sensitive because they straddle thermally sensitive terrain. However, as the pipeline route crosses similar terrain both to the north and to the south, the Applicant will have no alternative but to contend with this environmental problem.

Proposed borrow pit area P319 is located in a region containing numerous bluffs and exposures of good quality limestone suitable for quarrying operations. There is an unlimited quantity of easily accessible material availabe to meet the demands of the pipeline and Highway which either cross over or are located within a few hundred feet of several bedrock outcrops.

Proposed borrow pit 374 is located on one of many exposures of good quality limestone and dolomite on the west flank of Paige Mountain. As good quality, unconsolidated granular materials are lacking in this area, both pipeline and Highway will have to depend upon the bedrock to meet their material demands. The quantity of good quality rock is unlimited although it may be difficult to extract in some places because of environmental problems.

On the Applicant's maps proposed borrow area 374a is located on the southwest flank of Mount Thomas. Here, limestone and dolomite beds are exposed in the upper parts of steep cliffs most of which are covered with large quantities of talus. As it would be both difficult and expensive to develop a quarry in this area, it is believed the pit area is incorrectly located and should probably be in the extensive area of good quality glaciofluvial gravel which extends from the toe of the Mountain southwest across the pipeline right-of-way. The estimated 10 million cu yd of material available in this deposit should be sufficient to satisfy the local demands of both pipeline and Highway. However, as no good quality granular materials have been identified between this deposit and Fort Good Hope about 63 miles north, the demands may be large.

Proposed pit P289, situated on the edge of a glaciofluvial deposit of gravel and sand, is the first deposit of good quality, unconsolidated granular material north of Norman Wells. It is located between the proposed Highway and pipeline routes and will probably be used by both facilities. The Applicant will find it especially useful in building his proposed compressor station and communications tower on the right-of-way as well as a permanent 2-mile access road to a wharf on the Mackenzie River. The estimated 1.5 million cu yd should be sufficient to satisfy potential demands on the deposit. If not, an estimated 10 million cu yd of similar material exists one mile further north. P291 was proposed by the Applicant as an alternate to P289. However, it is unlikely that large quantities will be used from this source unless the supply of good quality material in P289 and adjacent deposits proves inadequate.

An estimated 1 million cu yd of good quality glaciofluvial gravel and sand exists at proposed borrow pit area 413 located close to the northern boundary of the Norman Wells community. The deposit lies between the proposed Highway and pipeline routes which at this point are about ¾ mile apart. Because of the lack of good quality, unconsolidated granular material in this area both facilities may make demands on this source. The estimated quantity appears adequate to meet this demand. A quarry developed in exposures of good quality limestone, which occur ½ mile south along the pipeline route, could be used to ease any shortage in this area.

Norman Wells to Great Bear River, Miles 373-421

Pit No.	Mileage	Distance from R.O.W.	Material
NW15	373	½ mi west Alt. to NW4	Glaciofluvial silt, sand and gravel
NW4	378	¼ mi east	Devonian dolomitic limestone
P290	388	east side	Glaciofluvial sand and gravel
P271	398.5	1½ mi east	Till veneer overlying limestone
P266X	401	¾ mi west	Till veneer overlying shale
P262	408	1½ mi east	Glaciofluvial silt, sand and gravel

Proposed borrow pit area NW4, located at the base of Kee Scarp some 2 miles east of the community of Norman Wells, is the chief source of construction materials for the community. The existing quarry was first opened to obtain crushed limestone aggregate during construction of the Norman Wells airport. Since then it has been operated intermittently to obtain materials chiefly for maintenance of local roads and other small projects throughout the community. There is no doubt that, if permission can be obtained, both the pipeline and Highway will make extensive use of the limestone. The quantity available has been estimated at 20 million-plus cu yd which, it is believed, is sufficient to fulfill the needs of both facilities with ample material remaining to meet community demand in the foreseeable future. The alternate source, NW15, also lies within the boundary of Norman Wells. The estimated 1 million cu yd of glaciofluvial silt, sand and gravel suitable for good quality general fill, is located close to the Highway which will probably make substantial demands upon it, if extraction from this deposit is permitted. However, as noted in the topic "Recreation Areas, Parks and Land Reserves", development of pits in this area could detract from recreational potential along Bosworth Creek.

According to the Applicant's maps, proposed borrow area P290 is located in the valley of Francis Creek on a terrace covered with thin, scattered deposits of glaciofluvial sand and gravel, along which the pipeline route runs for some 2 miles. The Highway route, located about ¼ mile west, is on a lower terrace covered with similar materials. The volume of available material in this area is small but it is doubtful that the Applicant requires large amounts. A deposit containing an estimated 1.5 million cu yd of good quality granular material occurs ½ mile upstream. It is doubtful if the Highway will have a demand on the material in P290 as similar material occurs along its right-of-way.

Proposed borrow pit P271 is situated at the south end of Vermilion Ridge in an area underlaid by good quality limestone covered in part by a thin veneer of till. There is a shortage of good quality unconsolidated granular material in the area and, consequently, the Applicant has decided to satisfy his material requirements for the compressor station and communications tower proposed for mile 400 from a limestone quarry at this site some 1½ miles to the east. There would be no demand from the Highway for limestone from this deposit as similar rock occurs along its right-of-way some 5 miles south. P266, which the Applicant has designated as the alternate to P271, is situated between the Highway and pipeline routes and lies in shale, covered in part with a thin veneer of till. The shortage noticed above applies also to this area. Thus both facilities will probably demand material from any quarry developed in the shale. More than 1 million cu yd is estimated to be available, which should meet demands from both facilities for fair quality general fill.

Great Bear River to Wrigley, Miles 421-551

Eleven preferred pits and one alternate are proposed for this stretch.

Pit No.	Mile-age	Distance from R.O.W.	Material
150BH	446	east side	Glaciofluvial silty sand
P242	459	1½ mi east	Glaciofluvial silty sand and gravel
P226	464.5	2 mi east	Limestone
P227	465.5	east side	Glaciofluvial sand and gravel
P213*	479	east side	Glaciolacustrine sandy silt (?)
P199	490	1 mi east	Limestone
P197*	495	5 mi west	Glaciolacustrine clayey silt (?)
P191	507	east side	Glaciofluvial sand and gravel
GM119	517	8 mi west	Glaciofluvial gravel
P133*	517	2 mi west	Glaciolacustrine silt (?)
P174*	533.5	½ mi west Alt. to P170	Glaciolacustrine silt (?)
P170	537	3 mi west of river	Alluvial sand and gravel along west side of Mackenzie River

*Location as plotted does not coincide with probable source.

For most of this section the proposed pipeline route is 1½ to 5 miles east of the Mackenzie Highway, except at miles 481 and 551 (Old Fort Point) where they are very close and at miles 430 and 540, where they cross one another. There is a shortage of fair to good quality, unconsolidated material in the area and consequently, as may be seen in the above table, the Applicant proposes to use glaciolacustrine silt as construction material. Some of the Applicant's borrow pit areas indicated as being in silt may, therefore, be incorrectly plotted. For example, alternate pit P174 may actually be located in the alluvial gravels of Whitesand Creek and not on the higher ground immediately to the west where glaciolacustrine silt occurs. Although miles 522-565 of the proposed route follow the base of the McConnell Range of the Franklin Mountains and in so doing either cut across or are close to several exposures of limestone, the Applicant seldom proposes a quarry in bedrock. It can only be assumed that requirements for this type of material are not sufficiently large to warrant opening a quarry.

With the exception of dune sand there is a lack of granular materials along both pipeline and Highway routes for 20 miles north of 150BH. Consequently, this pit, which is located in a deposit of fine-grained silty sand of glaciofluvial origin, will be in great demand by both facilities and there may not be sufficient material to meet the requirements. More field investigations are needed in the area between Big Smith Creek and Fort Norman to determine if there are deposits of granular materials which have not been identified.

Proposed pit P242, situated on the west edge of a small, irregular deposit of glaciofluvial silt, sand and gravel, comprises poor quality material suitable only as marginal fill. The Applicant probably proposes to use this material because there is a shortage of granular material in this area. The Highway will probably not require any material from this source.

Proposed area P226 is probably located on an exposure of good quality limestone instead of about 1 mile north as indicated by the Applicant. It will be a small quarry providing aggregate for construction of a communications tower. A winter road into the area from the right-of-way will require little material.

Proposed borrow pit P227 is located on the north edge of a deposit containing about 25 million cu yd of good quality glaciofluvial sand and gravel. About 1½ miles of the pipeline is also located on this deposit and it is believed a borrow pit could be developed almost anywhere along its length. Extensive deposits of similar material occur along the Highway route about 2 miles west; consequently it is doubtful if the Highway will require material from P227.

It is assumed that proposed borrow pit P213 is located in an area of glaciofluvial sand along the south side of Saline River although the Applicant shows it to be slightly to the east of glaciolacustrine silty sand. In this deposit of sand, there is an estimated 3 million cu yd of fair quality material, suitable as fill, which should satisfy pipeline and Highway demands. It is doubtful if the material in the sand deposit could be processed into one of better quality. Exposures of limestone about 3 miles north along the road are the nearest source of good quality material.

In borrow pit P199 the Applicant proposes to develop a quarry in good quality Middle Devonian limestone, of which there is an almost unlimited quantity in the area. It is doubtful if the Highway, situated about 2 miles west, will have a requirement for material from this potential quarry.

It is thought that the Applicant's location of P197—in glaciolacustrine silt about half way between two large deposits of good quality glaciofluvial gravel and sand—is incorrect. It should more sensibly be located on the elongated glaciofluvial deposit about one mile to the east along which the Highway runs for about 3 miles. The deposit contains an estimated 15 million cu yd, which is more than sufficient to satisfy local Highway and pipeline demands. The latter includes a road from the pit to the right-of-way, an airstrip, communications tower and compressor station.

Pit 191, located in an extensive deposit of good quality glaciofluvial sand and gravel intersected by Blackwater River, contains an estimated 30 million cu yd of material. This is considerably more than sufficient to satisfy local pipeline and Highway demands.

The Applicant has marked pit P133 in an area of glaciolacustrine silt. This may be located incorrectly and could be about one mile west on a small alluvial terrace where the silt occurs along the pipeline route. This would eliminate the need to construct a 2-mile access road. GM119, some 8 miles west, would provide the material to construct a helipad and the base of a small communications tower. The Highway would not require material from either pit.

Proposed pit P170 is located on a terrace, up to 1,000 feet in width, which runs for several miles along the east side of the Mackenzie River. The Applicant proposes to use the alluvial sand and gravel covering the terrace to construct a wharf on the river bank and a 5-mile access road to a compressor station on the right-of-way. Some conflict for these materials may occur between the pipeline and Highway which is located along the east side of the terrace.

Wrigley to Willowlake River, Miles 551-598

Except in the vicinity of Wrigley, the proposed routes of the pipeline and Highway closely parallel one another in this section. As a consequence, the two facilities may have a demand for material from the same deposits. However, the Applicant proposes only five pits whereas the Highway, considering an average haul distance of 2 miles, will probably require 12.

The extensive deposit of glaciofluvial gravel which underlies Wrigley and extends along the east side of the Mackenzie River both north and south of the community is the most important deposit of granular material in this area. Much of this material lies within the boundaries of Wrigley and may be reserved for community use or may be prohibited from use. DIAND consultants have estimated that some 40 million cu yd of good quality granular material, which is considerably more than the potential demand of the pipeline and Highway, is available outside the community boundaries. None of the Applicant's proposed pits lies within the boundaries of the community of Wrigley.

Pit No.	Mileage	Distance from R.O.W.	Material
P159	551.6	west side	Alluvial gravel
W5	566	1 mi west	Glaciofluvial gravel
P152	574	east side	Alluvial gravel
P146	579.5	1½ mi east	Glaciofluvial sand and gravel
P143	584.3	3 mi east, south side of River Between Two Mountains (Alternate)	Glaciofluvial silt and gravel

Proposed pit P159 is located on a deposit of good quality alluvial gravel crossed by the proposed route. At this point the Highway is aligned some 3 miles west, close to Mount Gaudet, where there are exposures of bedrock suitable for Highway construction. Thus, it is thought that the Highway will not require material from this pit.

Pit P152 is situated on the edge of an extensive area (10 million cu yd) of fair quality material. Both Highway and pipeline will need material from this deposit and it is believed there is sufficient to satisfy the demands of both.

The Applicant plans to develop pit P146 in a deposit of glaciofluvial sand and gravel about 3 miles north of the crossing at River Between Two Mountains. The deposit comprises an estimated 600,000 cu yd which should satisfy the combined Highway and pipeline demands, providing the former, to meet its demand for rip-rap and concrete aggregate for bridge construction, opens a quarry in the good quality bedrock exposed immediately north of the deposit.

Willowlake River to Burnt Island Crossing, Miles 598-644

Pit No.	Mileage	Distance from R.O.W.	Material
P139	598.5	3½ mi northeast of Willowlake River crossing	Glaciofluvial sand and gravel
P124*	620	5½ mi west Alt. to P118	Till (?)
P118*	620	3½ mi west	Till (?)
P109	642	east side	Glaciolacustrine sand

*Location as plotted does not coincide with probable source.

The Applicant proposes to open pit P139 in a deposit of glaciofluvial sand and gravel situated 3 miles northeast of Willowlake River crossing. If suitable bedrock cannot be located locally, DPW may want to process some of this material to produce concrete aggregate for use in the bridge

construction. The estimated deposit of 500,000 cu yd may not satisfy the demand on the two facilities plus the construction of the 3-mile access road.

The most important deposits of granular materials along this section of the route are those associated with an esker complex situated half-way between Camsell Bend and Willowlake River crossing.

At mile 620, where several utilities are planned (including an airstrip, communications tower and compressor station) the Applicant proposes to construct an access road west to the Highway. According to GSC maps, the materials in pit P118 and its alternate P124, both of which are close to the proposed access road, consist of till. These pit areas, it would seem, have been incorrectly plotted. The Applicant probably plans to use the fair to good quality granular material in the esker complex to construct both the access road and airstrip. Consultants to DIAND have estimated the esker complex to contain some 6 million cu yd of granular materials, which should more than meet the demand of the two facilities, which has been estimated at approximately 1.5 million cu yd.

Burnt Island Crossing to Fort Simpson Area, Miles 644-674

North of Fort Simpson the Mackenzie Highway is already under construction. To meet material requirements several borrow pits have been opened along its alignment and some 300,000 cu yd of gravel for road surfacing have been stockpiled at the Fort Simpson end. Even though the two facilities are in close proximity in this region, it seems there will be little if any conflict because most Highway requirements have already been met and the Applicant has not indicated an intention to use material from any pit located along the Highway.

The following are the Applicant's proposed pit areas:

Pit No.	Mileage	Distance from R.O.W.	Material
GM121	655.5	2 mi east	Alluvial gravel
None	658	½ mi west	Alluvial gravel
GM20	670	west side	Talus (?)
GM19	671	1 mi west	Lower Cretaceous sandstone, shale and conglomerate

Proposed pit GM121 and another with no number located about ½ mile west of mile 658 are adjacent to small streams and may be in environmentally sensitive areas. Proposed borrow area GM19 is considered to contain the most important granular material deposit in this section of the pipeline route. The material probably consists of thinly-bedded Lower Cretaceous sandstone and shale with more massive conglomerate beds. A quarry opened in these rocks would provide material suitable for construction of the proposed access road from mile 670, 10 miles northeast to the Highway. It is assumed the material in proposed pit GM20 consists of talus from the bedrock exposed in GM19, possibly mixed with glaciofluvial gravel. This would also be suitable for road construction.

Miles 674-730

The most important sources of information concerning granular materials in this section of the route are reports and maps prepared by GSC. It was not included in the areas recently investigated by the granular material consultants to DIAND. The following locations are suggested by the Applicant as potential borrow pit areas.

Pit No.	Mileage	Distance from R.O.W.	Material
GM87	680	Flood plain of Martin River	Alluvial sandy silt

Pit No.	Mileage	Distance from R.O.W.	Material
GM122	690	14 mi east, south side of Liard River Valley	Glaciolacustrine sand
GM97	699.5	east side, left side of Liard River	Glaciolacustrine silty sand
GM22	705	7 mi west, south side of Liard Highway	Glaciofluvial gravel
GM98	705	1½ mi west, south side of Liard Highway	Till
GM99	707	east side	Till
GM100	709.5	east side	Till
GM101	712.5	east side	Till
GM27	716.5	west side	Till, silty
GM25	717.5	5 mi west	Glaciofluvial silty gravel
GM90	730.5	west side	Till, gravelly, silty

With the exception of a possible demand for construction and maintenance materials along the Liard Highway, which crosses the pipeline at mile 705, there does not appear to be any other demand for construction materials along this section in the foreseeable future. The Applicant plans to use the Liard Highway as an access road from the Mackenzie Highway to the pipeline right-of-way. Maintenance materials for this short-term use of the Liard Highway could be obtained from pits GM22 and GM98, which were probably opened during its construction. The most important granular material deposit in the area is the glaciofluvial silty gravel in which proposed borrow pit GM25 would be located. Unless deposits of similar or better quality are found in the area prior to construction, there is no doubt the Applicant will develop one or more pits in this deposit. It would provide better fill than the till in which some of the proposed pits are located (unless the tills have a high stone content) or the glaciolacustrine silty sand along the left side of the Liard River. The proposed pit in the flood plain of Martin River, GM87, may be in an environmentally sensitive area. Borrow pit GM122, probably used during construction of the Mackenzie Highway, is thought to be too far from the right-of-way to be useful.

Coastal Route

Mile 342 was taken as the northern cut-off point for this review of individual borrow sites proposed by Canadian Arctic Gas; this point is the northern limit of the Granular Resources Inventory prepared by the consultants to DIAND.

West Mackenzie Delta to Peel River, Miles 342-431.5

This section of the pipeline follows the west side of the Mackenzie Delta on a slope which faces the delta and rises to the Richardson Mountains on the west. Nine pits are proposed for this area:

Pit No.	Mileage	Distance from R.O.W.	Material
GM127	348	2 mi west	Sandstone (?)
141	360.5	3 mi west	Shale, sandstone (?)
GM37	361	½ mi west	Alluvial gravel
GM128	375.5	2 mi east	Alluvial sand and gravel
142a	375.5	east side	Alluvial sand and gravel
142	376	½ mi west	Alluvial sand and gravel
143	385	1 mi west	Shale, limestone
147	407.5	1¼ mi west	Alluvial sandy gravel
GM38	409	1¾ mi west Alt. to 147	Alluvial sandy gravel

There is a lack of good quality granular materials along this section of the proposed pipeline route. One reason is the scarcity of glaciofluvial deposits which, along most of the route, provide the most satisfactory construction materials. Most

of the Applicant's proposed borrow pits are located in areas where bedrock is exposed along the base of the Richardson Mountains, especially in deeply incised stream valleys, or in alluvial deposits laid down by streams flowing out of the mountains. Both the bedrock and alluvial sources consist chiefly of shale and sandstone providing material of fair quality for general fill but generally unsatisfactory as concrete aggregate or for surfacing of roads and airstrips.

Proposed pit 147 and its alternate GM38 are located on alluvial deposits containing about 2.5 million cu yd of fair quality sand and gravel. DIAND consultants have indicated that, about a mile east of these proposed borrow areas, the pipeline route traverses an elongated deposit of good quality, glaciofluvial gravel and sand containing an estimated 2.5 million cu yd of material. It is suggested this glaciofluvial material be reserved for projects requiring good quality aggregate, such as surfacing the 6,000 foot airstrip proposed for the area, with the bulk of fill coming from the lower quality deposits.

Peel River to Junction with Richards Island Route, Miles 431.5-491.98

Pit No.	Mileage	Distance from R.O.W.	Material
237	432	3 mi south	Shale
GM39	432	¾ mi north Alt. to 237	Shale (?)
244	458	south side	Till
GM42	459	south side	Till
249	473	north side	Glaciofluvial sandy gravel
GM129	477	1½ mi north	Till
252	485	¾ mi south	Glaciofluvial sand and gravel

Two pits are proposed in the vicinity of the pipeline crossing at Peel River. Pit 237 is located in a quarry developed to provide shale and sandstone fill during construction of the Dempster Highway. The alternate, GM39, would probably provide similar material. The unlimited quantities of bedrock available will furnish both the pipeline and Highway with sufficient material during the construction and maintenance phases of the two facilities.

At the Mackenzie River crossing about 4 miles downstream from Arctic Red River the Applicant has proposed 2 borrow pit areas, GM42 on the right (east) side of the river and 244 on the left. Material in these areas probably consists of a thin veneer of till overlying shale. Quarries opened in the shale would provide the Applicant with fair fill material with which to construct a permanent 2-mile road to the Dempster Highway and also the proposed wharf and stockpile site at the Mackenzie River. It is doubtful if the Highway will require material from either source.

There will be no demand from the Dempster Highway for material from pits 252, GM129 and 249 as the Highway swings north at Arctic Red River on its way to Inuvik. Proposed pit 252 is on a large esker containing fair quality sand and gravel. The pipeline, which cuts across the north part of it, therefore has direct access to a large volume of general fill material. GM129 is in an area of till, which may form a thin veneer over shale bedrock in which the Applicant plans to develop a quarry. Pit 654 is located in an area containing some 2 million cu yd of good quality, glaciofluvial sandy gravel suitable for most construction purposes.

10.4 RECREATION AREAS, PARKS AND LAND RESERVES

Introduction

Installation and operation of the proposed gas pipeline represents a long-term commitment of land to a use not entirely compatible with recreation and conservation. The pipeline could restrict, or even eliminate, future options for certain activities or uses of land, and could lower the aesthetic or recreation quality of the area (*see* topic "Pipeline Inactivation and Abandonment"). While the total area involved will not be large, the linear nature of a pipeline means that disturbance will be widespread. For example, the proposed pipeline route crosses the entire length of the Yukon Coastal Plain detracting from the over-all wilderness qualities of this unique area.

In the past the isolation and the frontier nature of the regions have resulted in little need to establish parks, and in limited demand for recreational facilities in a formal sense. This situation cannot be expected to continue. The installation of a gas pipeline and accompanying development, the completion of the Dempster and Mackenzie highways and expansion of local population, coupled with the increasing pressures on parks and recreation facilities in southern Canada, will lead to increased recreational demand and will narrow the options open to set aside land for recreation, parks or ecological preserves.

The Applicant has provided some comment on land reserves in relation to his proposals. As developed in the following, the Assessment Group is of the opinion that impacts of pipeline development on land reserves and recreation potential warrant further and more specific appraisal, perhaps leading to some adjustment in the proposals.

Applicant's Data

Parks, wildland reserves, and wildlife refuges are discussed briefly by the Applicant in his description of the environmental setting "...along the Mackenzie River and in the northern Yukon prior to the introduction of the pipeline system" (Sects. 14.d.N.4, p.1; 14.d.N.4.10.7, p.119). The interaction of the pipeline with such areas and its impact on them has not been specifically discussed by the Applicant.

Concerns

Within the Northwest Territories and Yukon Territory, there are a number of locations where the proposed route may be in conflict with preservation/conservation and recreation interests. Additional concerns are involved where the route crosses existing and proposed wildlife sanctuaries, preserves and reserves and those areas proposed as ecological reserves under the International Biological Programme.

Kendall Island Bird Sanctuary

The northern terminus of the Richards Island branch of the proposed pipeline, with associated meter station, borrow pit, communications tower and helipad, lies within the southern part of the Kendall Island Bird Sanctuary. This terminal, of course, will connect to, and draw gas from, production facilities and gathering lines that are also within the Bird Sanctuary. Concerns over the combined effect of the pipeline and production facilities on migratory birds are outlined in the sections of this report dealing with "Snow Geese".

In the present context it should be noted that both the pipeline terminus and the accompanying gas production facilities are potentially in conflict with the basic concept of the Bird Sanctuary and will require permits from the Canadian Wildlife Service under the Migratory Bird Sanctuary Regulations of the Migratory Birds Convention Act.

Proposed Arctic International Wildlife Range (Canada)

It has been proposed that the northern Yukon from the Porcupine and Bell rivers north to the Arctic coast be set aside as the Arctic International Wildlife Range (Canada) primarily for the purpose of perpetuating viably large samples of natural ecosystems, including those wildlife populations on which traditional native ways of life depend (Calef, 1974). The proponents of the Range propose "...evolution of a management plan that would safeguard wildlife and environmental values without undue restriction on industrial activity" and resolve that various societal uses of the area, including pipelines, "...may be permitted on all or part of the range as will be determined by the management authority under such restrictions and regulations as are necessary..." (Resolutions of the Arctic International Wildlife Range Conference, 1970; "Uses"). It seems possible that the proposal for the Canadian Arctic Gas pipeline traversing the full length of the Yukon Coastal Plain might not be entirely compatible with the management concept of the proponents of the Range. The Assessment Group recognizes that the Yukon Coastal Plain section of the route crosses an area of particular environmental sensitivity.

Mackenzie Reindeer Grazing Preserve and Peel River Game Preserve

Mackenzie Reindeer Grazing Preserve and Peel River Game Preserve are each traversed by the proposed pipeline. Resource exploration and development are compatible with the concept of the preserves and are currently permitted within them. It would appear that development of the proposed gas pipeline would likewise be compatible under the terms of these two preserves.

Proposed Ecological Reserves—International Biological Programme

The proposed route of the pipeline transects three areas that are being considered as ecological reserves under the International Biological Programme/Conservation of Terrestrial Communities Section (IBP/CT), a world-wide research program concerned with preserving and safeguarding areas of biological or physiographical importance for the present and future scientists. One of the aims of the IBP/CT is to reserve samples of natural and semi-natural ecosystems for comparison with managed, utilized or artificial ecosystems. The criteria for site selection include sites that are of scientific interest because of the human management to which they have been subjected, even if this has, in some cases, led to more or less far-reaching modification of the biota.

The proposed Firth River IBP site (Mile 195-235) is considered to be a major scientific research site, representative of the unique north slope of the Yukon. The coastal plain and gently rolling foothills are an important, if not critical, component in the life cycle of a wide variety of

wildlife, including caribou, polar bear, waterfowl such as snow geese, raptors such as falcons and eagles, and overwintering fish such as Arctic char. The site also contains early archaeological evidence of man in North America. Although entirely within the boundaries of the proposed Arctic International Wildlife Range (Canada), the Tundra Panel of the Canadian Committee of the IBP/CT does not consider the Firth River site as being a managed multiple-use area (J. Lambert, pers. comm.). The presence of the proposed pipeline and its associated facilities would alter the wilderness aspect of this site and would not be compatible with the Panel's concept of the area.

The proposed Rat River IBP site is also transected by the proposed pipeline (Mile 407-418). The eastern portion of this site is of interest for botanical, glacial and wildlife studies and contains flora that range from Mackenzie River lowland species to those of the unglaciated alpine tundra. The construction of a pipeline is expected to degrade this site somewhat, although monitoring of the impact of the pipeline may be compatible with the purpose of the site. However, the ramifications of this impact deserve to be more fully explored.

The proposed Dolomite Lake—Campbell Lake IBP site (adjacent to Mile 95) is intended to preserve unique natural phenomena; in addition to containing a number of rare plant species, the site is an important raptor nesting area. The proposed route of the pipeline, adjacent to the site boundaries, will not threaten these plants or birds. However, one of the Applicant's borrow pit locations, indicated on route maps as belonging to the Department of Public Works, lies within the sensitive raptor nesting area. Further development of this pit would be incompatible with plans for protection of the critically important and sensitive falcon nesting area within this site.

Parks

The Applicant has noted that sites in the northern territories are being examined for possible designation as National or Territorial parks, but that there are no parks currently proposed along the pipeline route (Sect. 14.d.N.4.10.7, p.119). Further in this regard, the Assessment Group has learned that the Mackenzie River is being considered for designation as a National Historic Waterway, with the Waterway itself being primarily a management or planning concept, and that certain notable sites, or National Landmarks, are being considered as part of the Waterway. These National Landmarks would be protected as future interpretation or study areas, and recreational activities such as camping and fishing would not be permitted in them. The proposed pipeline could have an impact on these landmarks.

One site being considered as a National Landmark includes the Ramparts and the west bank of the Mackenzie River at Fort Good Hope (Mile 287). Although the pipeline will not affect this site directly, indirect effects are of concern.

The scenic attractions of the present village and the east bank of the river are compatible with, and contribute markedly to, the Historic Waterway and National Landmark atmosphere, but the extensive developments proposed by the Applicant, including a highly visible wharf, stockpile site and borrow pit, would be expected to have the opposite effect.

Another site that is being considered as a National Landmark is Bear Rock, just north of the settlement of Fort Norman (opposite Mile 420). The transmission tower presently slated for the top of Bear Rock is incompatible with the National Landmark concept and a location along the ridge to the east could be considered.

The Mount Gaudet and Roche-qui-trempe-à-l'eau area (opposite Mile 550) is also thought to be suitable for a National Landmark. The panoramic views possible from this height of land, as well as the presence of thermal springs and sinkholes, give this area considerable potential as a recreation/nature interpretation area. The communications tower proposed for Mount Gaudet would be in conflict with a National Landmark atmosphere, and of course, the pipeline route and facilities along the foot of the McConnell Range would detract from views from Mount Gaudet.

Recreation Areas

The proposed pipeline will affect a number of other areas with recreation or scenic value which deserve consideration as future recreation or park sites. One example of such an area is the Sandy Lake and Travaillant Lake region (approx. Mile 130-160). The Applicant states (Sect. 8.a. 1.5, p.6) that the Prime Route was moved approximately 20 miles westward to avoid this highly productive area for wildlife. This region may someday be considered suitable for a park that is able to meet future recreational needs of the population in the Delta region.

Recreational and aesthetic values of a number of similar sites are in potential conflict with pipeline development, as illustrated by the following examples:

(i) Compressor station M-10 (Mile 446) and the associated borrow pit are in an area of considerable recreational potential for travellers on both the Mackenzie Highway and the River. The historic Old Fort Point is suitable for development as a campsite/service area for river travellers. Noise and exhaust from the compressor could substantially reduce the attractiveness of this area for recreation.

(ii) Routing of the pipeline along the foot of the Norman Range (Mile 350 to 360), and particularly north of Mount Morrow, could have an adverse effect on the view of the spectacular cliffs as seen from vantage points along the Highway. Any disturbance of the talus cones and rock glaciers at the base of the slope (for instance, as sources of borrow) could be particularly disruptive in aesthetic terms.

(iii) A proposed alternate borrow pit at Bosworth Creek (Mile 373) near Norman Wells would overlap an area with scenic waterfalls and hiking trails. Development of the pit would detract from future recreational value.

(iv) Vermilion Creek, south of Norman Wells, has a spectacular canyon as well as remarkably deep limestone sink-holes. Development of the compressor station here and the borrow pit on Vermilion ridge, although some distance from the canyon and sink-holes, could have a negative impact on the recreational potential of the area.

The above examples are illustrative of possible interactions of the proposed pipeline development with potential recreational and park sites. A review of all such sites and interactions by the Applicant would provide a basis for assessing impact and identifying needs for adjustment of pipeline facilities or procedures, or remedial measures.

Highlights

1. The proposed pipeline route crosses or enters the Mackenzie Reindeer Range, the Peel River Game Preserve, and the Kendall Island Bird Sanctuary. In the first two areas, the pipeline does not appear to be in conflict with the purpose of these reserves. However, potential conflicts are involved in plans to locate the pipeline terminus and gas production facilities which feed the pipeline within the Bird Sanctuary. Permits from the Canadian Wildlife Service to build and operate these facilities will be required.

2. The pipeline route crosses the proposed Arctic International Wildlife Range for 134 miles on the Yukon Coastal Plain. This through-going development may not be entirely compatible with the concept of managed use of the area as seen by the proponents of the Wildlife Range. The Assessment Group recognizes that the Yukon Coastal Plain section of the route crosses an area of particular environmental sensitivity.

3. The pipeline route crosses areas which the International Biological Programme has proposed as ecological reserves at Firth River and Rat River, and also skirts the Campbell Lake reserve area near Inuvik. The proposed development is potentially in conflict with some of the concepts of the IBP proposals for these reserves. Consultation between interested parties aimed at resolving differences appears to be appropriate.

4. Possible interactions between pipeline development and possible National Landmark areas along the Mackenzie River deserve fuller review when plans for the latter reach a more definite stage.

5. Pipeline development will affect the recreation and scenic potential of a number of sites along the route but little specific information has been compiled regarding such interactions. Unnecessary impacts could be avoided if the Applicant were to prepare an inventory of such sites and interactions for review by the appropriate regulatory authority at the final design stage.

Literature Sources

"Arctic Ecological Reserves", Summary Document, Conservation of Terrestrial Ecosystems in the Yukon and Northwest Territories, under the auspices of the Canadian Committee for the International Biological Programme (undated).

Calef, G.W., 1974. "The Urgent Need for a Canadian Arctic Wildlife Range", Nature Canada, Vol 3, No. 3 pp.3-11.

"Resolution of the Arctic International Wildlife Range Conference", Whitehorse, Yukon Territory, October 20 to 22, 1970.

10.5 ARCHAEOLOGICAL SITES

Introduction

Throughout the twentieth century, archaeologists have conducted research in every area of North America toward the end of revealing the history of development of native peoples of this continent. This history comprises an important aspect of our cultural heritage. In addition to its significance as the only surviving record of the many North American cultures which developed no writing system, the archaeological reconstruction of North American prehistory and history has begun to shed light upon the relationship between man and his environment over a time span reaching back some thirty thousand years.

The evidence used by archaeologists in this reconstructive approach to prehistory consists of the remains of human occupations ranging in scope from small hunting localities to large villages. Most such sites are small and commonly consist of scattered stone and bone artifacts in an area only 10 to 20 feet across. Even the largest sites must be excavated with great care since the pattern of distribution of the artifacts usually contains the information needed to reconstruct a prehistoric village; the remains of structures, such as houses and caches, usually consist of little more than stains in the soil, and even such ephemeral traces are rare in most areas. It is important to emphasize that archaeological sites seldom contain the remains of the dead. Archaeologists seek the remains of settlements rather than burial grounds.

Regardless of the exact nature of the site, the chances of preservation are never very good. In order for the remains to be preserved they must first be buried and sealed within a unit of sediment or soil. Particularly in the North, where soil development occurs very slowly, it is the exception rather than the rule for the remains of human settlement to be buried and preserved as an archaeological site. Many sites consist of scattered concentrations of stone implements lying on the surface where they were deposited hundreds or even thousands of years ago. If a site is preserved through burial by wind- or water-carried sediment, it must later be exposed by some human or natural agency in order to be discovered. The exact nature or degree of exposure, however, is critical since widespread disturbance may destroy the site completely. In the North, where there is little widespread disturbance by man, known archaeological sites are relatively rare compared with more southern latitudes where a long history of agricultural development has revealed thousands of sites.

Recent land-use developments in the North have prompted accelerated surveys and excavations on archaeological sites of many different kinds. Such land-use operations can be seen as a double-edged sword since, on the one hand, they reveal the sites for study while, on the other hand, they may destroy the sites and the information they contain. One role of the archaeologist must be the constant surveillance of major land-use operations so that newly exposed sites can be salvaged in such a way as to minimize the loss of information. The importance of this process in Canada is increased by virtue of the geological history of the region. Nearly all of Canada was buried beneath repeated advances of glacial ice, the last of which completely erased any record of prehistory which might have been preserved prior to the Wisconsin maximum of 15,000 years ago. Only one major area, the interior of Yukon Territory, lay outside this ice mass and offers some hope of containing earlier remains of human occupation in

Canada. The interior regions of both Alaska and the Yukon remained free of ice due to lowered precipitation in the relatively dry Arctic, and this "Beringian refugium" will soon be the focus of renewed research efforts designed to seek further evidence of the first human occupants of the New World.

The earliest dated artifacts yet discovered in the New World have come from the northern Yukon Territory where there is evidence that man was present around 30,000 years ago. None of these earliest finds has been recovered from its primary site of deposition, however, and it is hoped that undisturbed deposits will soon be found. A long time gap lies between these earliest finds and the next recognizable and datable archaeological remains in northwestern Canada. Several sites in the Yukon and Northwest Territories are believed to be approximately 8,000 years old; these sites are undisturbed settlement deposits which together have provided fairly detailed evidence for the last 8,000 years of prehistory and history.

A universal problem in northern interior archaeology is the small size of the sites and the samples that can be obtained from them. Human population density may never have been very high in the North, and the paucity of material only serves to emphasize the importance of each and every well documented find. It is quite justified to characterize the archaeological record as ephemeral and non-renewable (Wright 1969), and this fragile source of information is jeopardized by any form of land use which involves widespread disturbance or submergence of the surface of the earth. Paradoxically the very process of recovering archaeological information—that of scientific excavation—is a destructive process in the sense that the excavation can be conducted only once. It is for this reason that the excavation must be very carefully controlled and accompanied by many forms of documentation such as detailed mapping, profile drawing, and photography. In many cases, it is preferable to preserve a site rather than to excavate it. An excavation should be conducted only when an archaeologist has defined a research problem for which a given site may provide an answer. Archaeologists have been obliged to undertake excavations of sites without first formulating a specific research design, owing to pressures from land-use operations and natural erosion that could well destroy the site; such emergency excavations are known as salvage archaeology.

Concern can be focused on two kinds of problems. One is the protection of those known archaeological sites that warrant preservation or salvage excavation. The other is to ensure recovery of as much information as possible from sites that are presently unknown but which may be discovered during construction of the pipeline and related facilities and associated land clearing.

Applicant's and Other Data

Archaeological research conducted in the North during the past 30 years has resulted in the discovery of several hundred sites in the vicinity of the pipeline route. Most of these sites have been found during the past few years as a result of survey operations carried out in anticipation of pipeline development and in connection with the construction of the Mackenzie and Dempster highways. The principal projects carried out to date include: (1) a proposal commissioned by the Applicant (Millar, 1974); (2) an earlier similar study commissioned by Mackenzie Valley Pipe Line Research, Ltd. (Millar, 1971); (3) an archaeological impact study along the Mackenzie Highway right-of-way (Dept. of Public Works, 1973); (4) a general corridor study by the Government of the Northwest Territories (Millar, *et al.*, 1973); and

(5) a three-year study along the pipeline corridor carried out for the Dept. of Indian Affairs and Northern Development by the National Museum of Man (Cinq-Mars 1973, 1974; in preparation). New archaeological sites have been reported by every party fielded in the area, and some of the newly discovered sites are of considerable importance.

In addition to assembling a large body of archaeological data, the two reports thus far completed by Cinq-Mars (1973, 1974) set forth a number of recommendations in support of the "Expanded Guidelines for Northern Pipelines", but these recommendations apparently have not been considered in the application. Neither the Applicant's proposals nor the archaeological report submitted with these proposals (Millar 1974) incorporates up-to-date information on the known archaeology of the corridor, and many of the data referenced on the Alignment Sheets are inexact and/or irrelevant because the sites are some distance from the proposed right-of-way (*see* Alignment Sheets 1B-0200-1015 and 1032 and others).

The archaeological program proposed by the Applicant can be summarized as follows (Sect. 14.d.N. 6.3.8, p.11): (1) preliminary surveys will be carried out in areas selected on the basis of priority classification; (2) both before and during construction, sites will be avoided or flagged; (3) those sites which cannot be avoided will be salvaged by archaeological excavation crews; (4) construction personnel will be given basic training in artifact identification; and (5) artifacts resulting from the work will be deposited in appropriate public repositories.

Concerns

General

The most important concern is that the Applicant's proposals for an archaeological salvage program are based upon a concept of priority classification which the Assessment Group regards as suitable only for the most preliminary stages of the operation (Sects. 14.d.N.2.1.4, p.2; 14.d.N.3.5, p.10; 14.d.N.6.3.8, p.11; 14.d.S.16.11, p.5). The major failings of the approach set forth by Millar (1974, 4.4) stem from its reliance upon logistics and known site distributions as significant factors in classifying sections of the line and from its exclusive focus upon modern land-forms as indicators of potentially productive localities. With reference to the first problem it can be shown that the distributions of known sites are closely related to modern logistic facilities and may seldom if ever reflect the real patterns of prehistoric human occupations. As an example of the second problem, all muskeg areas are regarded as being low priority since sites are hard to find there and since they are not now suitable for human habitation during much of the year. There is no explicit appreciation of the fact that such areas may not have been characterized by muskeg until relatively recent times and that even now such areas are suitable for winter use and travel. Although the Assessment Group acknowledges the usefulness of a priority classification in the earliest phases of archaeological survey, it considers more appropriate a plan which closely links archaeological surveillance with the construction schedule regardless of the nature of the modern terrain and vegetation pattern.

Pre-Construction Activities

The Applicant states that an archaeological survey of selected high-priority sections and localities will be carried out ahead of construction activities either before or accompanying preliminary surveys and preparation activities (Sect. 14.d.N.6.3.8(2)) but specific sections are not identified in the Applicant's proposals. The Assessment Group identifies the following priorities in this regard.

1. The entire route from Richards Island to the junction with the Prudhoe Bay line and the shorter section from Parsons Lake to the main line remain to be surveyed for archaeological sites even in a preliminary way. Helicopter reconnaissance guided by a priority classification approach might be adopted for such surveys since they would be conducted on the basis of a corridor concept rather than along a marked route.

2. Surveys and salvage archaeological work at the proposed crossings of the Firth, Hare Indian, and Willowlake rivers would reduce the impact of construction on the large concentrations of sites already known there. In the case of Firth River, a realignment of the right-of-way to a more northerly position might reduce the danger to archaeological deposits, but a more suitable location cannot be specified until the archaeological potential has been evaluated on the ground.

3. A number of proposed stream-crossing localities which have not been examined for archaeological sites appear to have more than usual potential, but are subject to intensive construction activities related to nearby compressor-station pads and other facilities. Although no archaeological work has been done at these crossings, they could be examined quickly in a pre-construction reconnaissance if suitable logistic support were available. Such crossings include the Swimming Point crossing of the Mackenzie River, the crossings of Rengleng River, Thunder River, Donnelly River, Hanna River, Oscar Creek, Vermilion Creek, Big Smith Creek, Saline River, an unnamed creek at mile 387, the River Between Two Mountains, and the Mackenzie River at mile 643.7 on the main line. Similar crossings on the coastal route include the Malcolm River, Rapid Creek, Beaverhouse Creek, Willow River, and the eastward-flowing Rat River.

4. It would be most useful if the location of all wharf sites along the Mackenzie River and the Yukon coast were marked as closely as possible on maps provided to the archaeological project. Since equipment and supplies must be moved into such wharves immediately upon the initiation of the location survey, there will be too little time for archaeological reconnaissance once the project has begun.

Facilities and Borrow Pits

Prior to the location survey, all archaeological work would have to be done on the basis of a corridor concept since adequate on-the-ground data points will not be available until the boundaries of all facilities are marked (Sect. 13.a.6.2). For those spreads scheduled for first construction, there will be very little time available for detailed archaeological work between the completion of the location survey and the beginning of construction on station pads, airstrips, roads, stockpiles, and communications towers. Likewise the use of associated borrow pits will begin very soon after their boundaries have been marked. Since the schedule calls for excavating borrow pits and constructing station pads during the winter, there will be very little time for archaeological survey of either pits or pads between the time they are marked and the time they are modified by use and construction. This problem may

be particularly acute in the case of borrow pits since elevated, well-drained areas such as terraces and eskers commonly yield archaeological materials. It is difficult to assess the archaeological potential of the borrow pits since their individual sizes are not indicated in the Applicant's proposals. On those spreads where facilities are to be constructed in the second and third winters, there should be ample time to complete archaeological work if the location survey is carried out according to the schedule in Section 13.a.2.3.1.

Right-of-way Clearing

Many portions of the right-of-way can be adequately examined as soon as the construction survey has provided on-the-ground markers along its boundaries. However, there are many heavily forested areas which cannot be effectively surveyed until clearing has been completed. In such areas, the archaeological inspection would occur in the summer following clearing and preceding grading and ditching. The Assessment Group is concerned about those portions of the line south of 65^{o} Lat. where conventional techniques may include extensive disturbance of the surface during the clearing operation. Even where Arctic construction techniques are used (Sect. 13.a.6.3, p.30), the technique of "high-blading" would be preferable to the use of blade shoes in the interest of minimizing degradation of the surface and possible destruction of archaeological sites.

Grading and Ditching

As provided in Section 14.d.N.6.3.8(2), archaeological crews will accompany all ditching and other construction activities on the line in order to identify and salvage archaeological sites exposed in the course of excavation. The Assessment Group recognizes the great contribution the ditch itself may make to the discipline of archaeology but is concerned about the timing of activities in the ditch. Assurances are needed, for example, concerning the feasibility of an archaeologist working with other personnel to examine and document the walls of the ditch following excavation but prior to lowering in the pipe. Scheduling details such as the normal pace of a single ditching operation, the number of ditching operations on a single spread, the duration of a day's work, the number of work shifts planned for a given ditching operation, and the availability of artificial lighting during long winter nights comprise essential information for estimating manpower needs on the archaeological aspect of the project. Techniques of flagging newly discovered sites will be so designed that later construction activities will not disturb or destroy the markers.

Post-construction Activities

There appear to be no guidelines in the Applicant's proposals concerning the access to the right-of-way following the construction period. With respect to archaeology, it would accomplish little to flag newly discovered sites unless access to the right-of-way is assured for later investigations of such deposits. Since the stability of the pipe and the effectiveness of erosion controls could be affected by archaeological excavations in the right-of-way, a detailed understanding will be needed concerning the conditions of any such excavation after pipeline construction has been completed. Furthermore, such post-construction excavations, and associated laboratory work are viewed by the Assessment Group as an integral part of the pipeline archaeological salvage program, in terms of both organization and funding.

Other post-construction activities should include sufficient time and funds for analytical work on

collections resulting from the project as well as the preparation of an over-all preliminary report within a year of the completion of all phases of construction.

Manpower and Personnel Training

The Applicant's proposals include reference to an archaeological advisor as well as plans for an orientation seminar for "supervisory and inspection personnel" (Sect. 14.d.N.2.2.6, p.15) and "construction personnel" (Sect. 14.d.N.6.3.8(6)). The Assessment Group supports the concept of an orientation seminar and the inclusion of archaeological identification and reporting procedures in the environmental training program, but it notes that the foregoing concerns indicate the need for an archaeological program of considerable scope. It is likely that at least a dozen archaeologists and students will be required throughout the period of survey and construction, and that staff would be augmented during the summer seasons by the requirements for increased manpower on salvage excavation crews. It must be made explicit that the burden of routine site identification cannot be left to construction personnel and their supervisors but must instead be carried out by professionally trained archaeologists and students. The requirement for trained excavation crews could be met in part by implementing the recommendation of Cinq-Mars (1973, 9.2.9) that native people be trained to do this work.

Project Organization

Neither the Applicant's proposals nor the archaeological report submitted with these proposals (Millar 1974) contains an outline for the organization of the archaeological project. Existing policies on the federal and territorial levels will have considerable bearing upon the over-all organization, and most of the route is proposed for land which falls under the jurisdiction of one or more archaeological sites regulations. As the sole federal agency responsible for prehistory on federal crown land, the Archaeological Survey of Canada, National Museum of Man, National Museums of Canada will play a key role in the project. In particular, the Assessment Group draws attention to the following recommendation of the federal archaeology study:

> It is recommended that discussions be initiated between the National Museum of Man and the agency responsible for pipeline construction in order to define as soon as possible the operational measures which will be required to implement a full-scale salvage program. This should be done well in advance of actual pipeline construction and in conjunction with the various researchers who will actually carry out the salvage program. (Cinq-Mars, 1974, 8.2.1.)

Highlights

1. The proposed pipeline development would provide unique opportunities for discovery of archaeological sites, but, on the other hand, it could lead to destruction of archaeological materials. Archaeological salvage measures ideally would take full advantage of the opportunity of access provided by the project and would minimize destruction of prehistoric and historic information.

2. In accordance with the pipeline guidelines, the Applicant proposes salvage archaeological work in conjunction with his construction project.

3. In the view of the Assessment Group, this pipeline archaeology program logically would include: (a) field work on certain selected localities prior to pre-construction or construction work by the Applicant; (b) field work on all facility localities as soon as the Applicant has inaugurated his location survey; (c) field work

on most portions of the right-of-way following clearing but prior to grading and ditching; (d) field work during all grading and ditching operations toward the end of examining the ditch walls prior to lowering in the pipe; (e) excavation of newly discovered sites either during or after the construction period; and (f) one year of post-construction laboratory and library work toward the end of preparing an over-all report on the program. Particular attention is drawn to (e) and (f) owing to the likelihood that time constraints during (b), (c), and (d) will leave much work incomplete.

4. An archaeological program for a project of this magnitude would require a permanent staff of at least a dozen archaeologists and students, and additional manpower needs would arise during the summer seasons.

5. In addition to instructing pipeline construction and inspection personnel to recognize archaeological materials, it would appear appropriate to train native people to work on excavation crews whenever possible.

6. Appropriate consultation with the Archaeological Survey of Canada, National Museum of Man, National Museums of Canada, will be of prime importance in establishing the organization, terms, and personnel of the archaeological program.

7. Archaeological salvage work along the pipeline right-of-way and in its associated facilities would be more effective if it were scheduled in terms of the construction sequence rather than on the basis of priority classifications based upon the probability of discovering new archaeological sites.

8. The Firth River crossing would avoid a known concentration of important archaeological sites if it were relocated toward the north. A more desirable position from the standpoint of archaeology cannot be specified until the area has been examined in the field.

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CHAPTER 11

ALTERNATIVE CORRIDORS AND ROUTES

11.1 ALTERNATIVE CORRIDORS

Introduction

The "Expanded Guidelines for Northern Pipelines" require that an Applicant must provide "...comparison of the Applicant's proposed route with alternative pipeline routes, in terms of environmental and social factors..." The Applicant has distinguished between routes and corridors; in Sect. 14.e.1.1 he points out that "...it is useful to differentiate between what will be called 'corridors' and what will be called 'routes'. 'Corridor' is here used to indicate a general pathway through a relatively independent area, quite distinct from other corridors. The term 'route' is used to indicate a specific alignment for the pipeline, within a corridor." He goes on to state that he "...has indicated five basic pipeline corridors in Alaska and northwestern Canada, and..has examined each."

Applicant's Statement

The four alternatives to the Prime Route examined by the Applicant are:

- the Interior Route
- the Offshore Corridor
- the Fairbanks Corridor
- the Fort Yukon Corridor.

The preferred alternative to the Prime Route is the Interior Route, which is examined later in this chapter and compared with the Prime Route.

The Offshore Corridor

This would involve an underwater pipeline roughly paralleling the Arctic coastline, joining the Prime Route near the Alaska-Yukon border. The Applicant indicates that he could not build such a line in the time proposed, nor could he ensure its prompt repair if interruption occurred during freeze-up or ice break-up periods, primarily because of the present state of the pipelining art in respect of coastal areas that have substantial ice cover. The environmental and socio-economic implications of the corridor would differ in only minor degree from those already expressed in the Prime Route application. The Applicant further declares that both construction and operating costs would be vastly greater than those for the Prime Route.

The Fairbanks Corridor

This corridor would run south in Alaska to Fairbanks, thence into southern Yukon. It would generally follow the Alaska Highway into Canada, past Whitehorse, Watson Lake, across northwestern British Columbia, and on to a junction with the Prime Route in central Alberta. The corridor would be longer than the Prime Route by some 1,000 miles and would pass through an area of high seismic risk as well as difficult terrain, including more

than double the Prime Route mileage of discontinuous permafrost.

The Fort Yukon Corridor

Although passing somewhat north of it, this corridor is similar in many respects to the Fairbanks Corridor concept. It is some 500 miles longer than the Prime Route. This corridor would enter the Yukon Territory just north of the Yukon River. It would follow the Yukon Highway system via Dawson, Pelly Crossing, Ross River and Watson Lake, and then on across northern British Columbia and join with the Prime Route in central Alberta.

The Applicant points out that neither of these latter routes uses the Mackenzie River Valley, but would require another corridor extending south from the Mackenzie Delta, through the Yukon, to a connection with Fairbanks Corridor near Whitehorse, or with the Fort Yukon Corridor just east of Dawson. This south-trending gas supply line would approximately parallel the existing and proposed route of the Dempster Highway.

Commentary

The Fairbanks and Yukon corridors and the branch corridor connecting them to the Mackenzie Delta gas fields lie outside of the broad "corridors" formally identified in the "Expanded Guidelines for Northern Pipelines."

From a socio-economic point of view, it would appear that local residents of the Yukon would not have difficulty in coping with the presence of such a major project in either of these two corridors. Mineral development, highway development, hydro developments, pipelines, airfields, etc. would seem to have accustomed the people of the southern Yukon to the impacts of large-scale developments. However, serious shortages of labour supply could arise if a pipeline project were to attract labour from the limited labour force that both industry and government depend on to fill their local requirements. The presence of a pipeline along these routes in the Yukon possibly would make gas available locally and for existing and potential mineral development operations.

In environmental terms, the well established access and pre-existing development along Canadian parts of both the Fairbanks and Fort Yukon corridors would serve to limit concerns over terrain or ecosystem disturbance. Although some sensitive permafrost terrain would be involved, the amount of such terrain would not be great. The branch corridor to connect these corridors to the Mackenzie Delta, however, would pass through an area with much permafrost and with a variety of environmental sensitivities. The existence of the Dempster Highway would serve to reduce some environmental impacts by providing ready access, although interaction between the two facilities could raise additional issues. These corridors would involve crossings of a number of large rivers, which could lead to concerns over impact on fish and particularly salmon.

11.2 THE INTERIOR ROUTE - ENVIRONMENTAL IMPLICATIONS

Introduction

The "Interior Route" has been proposed by the Applicant as an alternative to the Prime Route between Prudhoe Bay, Alaska, and the west bank of the Peel River, N.W.T. The principal environmental consequences of building a gas pipeline along the Canadian portion of the Interior Route, to the point where it follows the alignment proposed for the Prime Route, are assessed in the following paragraphs. This portion of the Interior Route is 178 miles in length.

Discussion of the Interior Route differs in organization and scope from the pattern used in other topic sections in this volume. The Interior Route is the only alternative given "route status" by the Applicant by virtue of Alignment Sheets; other alternatives are only broadly treated as "corridors". The Interior Route can therefore be treated fairly specifically as a geographic entity, bringing together many of the environmental concerns and principles developed for the Prime Route which are presented elsewhere in this volume.

Implications of building a pipeline along the Interior Route are examined in terms of the Applicant's statement as well as other available data for the entire range of environmental concerns.

This is not a detailed assessment; only the salient considerations are discussed. For details in rationale related to any particular environmental subject, it is necessary to refer to statements prepared for the Prime Route.

Applicant's Proposal

Route

The Interior Route alternative trends southeastward across the Brooks Mountain Range from Prudhoe Bay before turning eastward into the Yukon. At this point it is south of the British Mountains, approximately 120 miles south of the Arctic Coast and 1,200 feet above sea level. The proposed route follows the north flank of the Old Crow Range and crosses the Old Crow River approximately six air miles north of the village of Old Crow. East of the river the proposed route follows the southern edge of Old Crow Flats for 20 miles. From there it follows the north bank of the Porcupine River for 20 miles and is less than 1,600 feet from the river in some places. It continues eastward to the Bell River at Lapierre House, across the Bell and up into the Richardson Mountains along the Rat River Valley. After crossing the crest of the Richardson Mountains at 2,680 feet the proposed route descends the fairly gentle east slope for 35 miles to the west bank of the Peel River near sea level. The crest of the Richardsons marks the boundary between the Yukon Territory and the Northwest Territories. The Yukon portion of the Interior Route is 140 miles long; the Northwest Territories portion prior to intersection with the Prime Route is nearly 40 miles.

The entire Canadian portion of this route lies within the zone of continuous permafrost as designated by Brown (1967). The Applicant presents data from a number of drillhole logs that show a highly variable ice content in unconsolidated sediments, particularly on the lower slopes. Pure ice in excess of 14 feet thick is reported locally, although generally ice contents in excess of 100 per cent (water content relative to dry weight of

sample) occur only in the upper 6 to 8 feet.

The area crossed by the proposed Interior Route consists of two broad regions with contrasting terrain—an eastern region where the character of the landscape has been molded by glaciation and a western unglaciated region.

The unglaciated region, which extends from the Alaska-Yukon border to about two miles east of the crest of the Richardsons, is characterized by broad, smooth, ridge crests underlain by deeply weathered bedrock; by the absence of glacial sediments; and by the presence of lake silts and clays in valley bottoms below about 1,100 feet. In this region surficial materials generally occur in gradational sequence consisting of weathered bedrock (mostly argillite and quartzite) on the ridge crests; a thin veneer of stony and silty colluvial veneer on the upper slopes; a thickening silty and sandy mantle of slopewash materials on the middle slopes; and thick sandy, silty, and clayey lake sediments on the lower slopes below about 1,100 feet. Ice content in near-surface materials generally increases downslope as the sediments become finer grained and better sorted. Slopes for the most part are gentle, although the west slope of the Richardsons has local relief of over 500 feet within half a mile. Surface drainage west of the Richardsons is either northward into Old Crow Flats or southward and southwestward into the Porcupine River. Ultimately, all drainage along this portion of the proposed route enters the Porcupine River, which flows westward to join the Yukon River at Fort Yukon, Alaska, thence westward to the Bering Sea.

The glaciated region extends from the Richardson Mountains eastward to the Peel River. Where bedrock is exposed, it stands up as sharp resistant ridges. Most of the proposed route in this region is characterized by gentle, slightly dissected, till-mantled slopes. Steep slopes occur in some places along abandoned channel systems and along the descent from the Peel Plateau to the Peel Plain. Ice-rich sediments are encountered in the last 20 miles in hummocky till and in silts associated with the Mackenzie River Delta. Surface drainage flows eastward to the Peel River.

Vegetation along the Interior Route varies from mature, close-crowned stands of white and black spruce at altitudes below about 1,200 feet to treeless alpine meadows above 1,800 feet. Slopes at intermediate altitudes have a cover of low willow and dwarf shrubs. A thick ground cover of moss and lichen is common.

Technical Elements

Along the 178 miles of Interior Route the Applicant is proposing to locate:

- four compressor stations about 40 miles apart
- one measurement station
- nine communications towers
- three new airstrips (two 2,400 feet long; one 6,000 feet long)
- ten helipads (including one heliport)
- 24 miles of permanent access road
- 186 miles of temporary winter road (in addition to winter "trails")

Construction will require a total of 4,600,000 cu yd of borrow, much of which is weathered bedrock.

The pipe will be buried throughout its length, with the top of the pipe two and a half feet below grade.

Permanent roads are of two types:

(i) short sections which are generally less

than a mile in length provide service links between airstrips and compressor stations;

(ii) a 12-mile section linking the Dempster Highway to the alignment about ten miles east of the crest of the Richardsons.

Temporary winter roads are also of two types:

(i) short sections over which borrow can be transported to the alignment from the source, or along which construction access can short-cut a steeper portion of the alignment;

(ii) longer sections linking the Dempster Highway to the alignment near the confluence of the Bell and Rat rivers and near the village of Old Crow.

Schedule of Activities

Construction of the Interior Route would involve three spreads and would follow the schedule presented below, according to the documents submitted by the Applicant in March 1974. The right-of-way would be cleared in the winter of 1977-78, and construction would be started and completed between December, 1978 and April, 1979. Stockpiling of materials would be by road and air. Some pipe would be stockpiled via temporary winter road near to Old Crow in the winter of 1977-78 and some would be directly strung via this road during the 1978-79 winter. In each case the pipe will have been stockpiled on the Dempster Highway in the preceding summer. The temporary winter road to Lapierre House would be used in the winters of 1977-78 and 1978-79 to pass pipe from a stockpile on the Dempster Highway. A permanent road from the Dempster Highway east of the crest of the Richardsons would be used to transport pipe in the winter of 1978-79. From here eastward, pipe would be delivered by barge to the Peel River in the summer of 1977. It is proposed to move chilled gas through the pipe in the spring of 1979, upon completion of the line to Prudhoe Bay, Alaska.

Physical Environment

Terrain. The principal aspect of terrain stability that constitutes an environmental concern in the construction, monitoring, and repair of a pipeline is local susceptibility to soil erosion. This, in turn, is commonly related to disruption of surface drainage and generation of thermal instability in soils containing high content of excess ice. Sloping terrain, ice-rich sediments, steep grades, and river banks are loci of terrain vulnerability, particularly during summer when the unfrozen sensitive active layer is highly susceptible to disturbance by running water or mechanical equipment.

In view of these interrelationships, the most desirable route would minimize the steep grades and river banks to be crossed and would follow drainage divides, both major and minor, where the ground is less susceptible to erosion because of the absence of organized surface drainage, and because the soil materials are thin (over bedrock), relatively coarse, and contain less ice than in lower sites.

The Applicant's Interior Route proposal does not adhere closely to the above principles of route location:

(i) For 20 miles east of the Old Crow River, a route about three miles farther south would follow the crest of the low east-west ridge dividing the Porcupine drainage from the Old Crow Flats. Ice-rich lake sediments and slopewash that mantle the lower slopes would be avoided; surface drainage ways would be fewer and con-

siderably smaller and would present less of a problem to maintain.

(ii) Near the confluence of the Bell and Rat rivers, the proposed route crosses both rivers. In order to do this it crosses three times the unstable scarps developed in thick, ice-rich, lake sediments that border the alluvial meander plains. Old slide scars indicate the natural instability of these slopes. A route that approached the Bell River from the northwest, from behind the nearby bedrock ridge, then crossed the Bell upstream from its confluence with the Rat would reduce the stream crossings to one, reduce the unstable scarps encountered to two, and avoid more than two miles of ice-rich lake sediments.

(iii) East of the Richardsons the till plain is gently but densely dissected and the proposed route trends at an angle across the drainage systems. Minor route changes to follow the shallow divides would minimize erosion problems.

River crossings, with attendant problems of terrain stability, siltation, and pipeline integrity, can also be made less disruptive by adopting, where possible, the principle of routing along or near the drainage divides. In such situations, streams are smaller and there is less possibility of winter flow that would complicate the crossings from both environmental and engineering points of view. Where steep scarps border the river plain, they should be traversed where the products of locally accelerated erosion could be arrested on the floodplain before getting into the stream. The possibility of interrupting perennial groundwater flow in the alluvium by creation of a frozen bulb around the buried pipe should be investigated for each river. Such an interruption could generate an aufeis and subsequent local erosion could be severe.

Some of the larger streams that would have to be crossed by an Interior Route are the Old Crow River, Driftwood River, Berry Creek, Waters River, Bell River, and the North branch of the Rat River near the headwaters. Winter flow has been reported on occasion from most of these rivers.

The Interior Route as proposed crosses no lakes, although the route comes within 2,500 feet of thermokarst lake basins in various places. Thermokarst basins are indicative of a high content of excess ice in the associated sediments, and of high susceptibility to erosion. The risk of accelerated erosion resulting in a siltation problem in the ecologically important lakes could be decreased, in most cases, by minor relocations of the route.

Abandoned high river terraces, deeply weathered bedrock, and alluvium from the active river beds are locally designated as extraction sites for borrow material. For many of these, additional information on the size and shape of the proposed borrow pit is required for assessment of environmental impacts. This is particularly important for the sites in active river beds where sediment transport rates, bank and bed stability, siltation potential, and thermal characteristics of the river bed must all be considered in assessing potential effects on fish.

In summary, many problems of terrain instability due to presence of ice-rich sediments on lower slopes, interruption of surface drainage, and steep unstable slopes could be alleviated by minor relocations of the proposed route. Placing the route closer to local drainage divides would, in most cases, lessen the potential for terrain instability.

Seismicity. The Applicant has noted that, since 1940, earthquakes up to magnitudes of 6.5 on the Richter scale have been recorded within a few miles of the proposed route where it crosses the Richardsons. Direct and indirect effects of such earthquakes potentially could damage or rupture the gas pipeline; the Applicant has indicated a variety of design options that will be considered to guard against pipeline damage resulting from seismic activity. Slope failures and liquefaction of saturated sediments could be associated with earthquakes, and such failures could be localized along the pipeline where construction has reduced the natural stability of the ground.

Archaeology. The earliest dated artifacts yet discovered in North or South America have come from the northern Yukon Territory. Construction of a pipeline along the proposed Interior Route would afford an opportunity to acquire significant new information about the history of early man in the Americas. The Interior Route is judged to be archaeologically the most important of all regions proposed by the Applicant for potential pipeline sites. It is noteworthy that the native people at Old Crow village take a great interest in local archaeological information.

Archaeological concerns are two-fold—the protection of unusually important sites, and the salvage of as much information as possible from sites that may be discovered along the right-of-way. A number of sites close to the proposed route are not mentioned on the Applicant's Alignment Sheets: three sites near the crossing of Old Crow River, two of which are within 2,000 feet of the proposed route; one site near the proposed borrow pit for compressor station IA-08; two sites within 2,000 feet of the route about two miles east of Rat Indian Creek; three sites on the Porcupine River bluffs about three miles east of Berry Creek; two sites near the road and airstrip proposed to serve compressor station IA-09; and an important site within 2,000 feet of the alignment about seven miles west of the crest of the Richardsons.

Some sites are so important that every effort should be made not to disturb them. The temporary winter road linking the route near Old Crow village to the Dempster Highway crosses the Porcupine River near the important Klo-kut and Old Chief sites. Heavy use of this road for staging of pipe materials to Spread "A" would threaten these sites and potentially important adjacent terrain. Consideration should be given to have this temporary road cross the Porcupine River about four miles farther downstream before swinging north along the east bank of the Old Crow River. The important Rat Indian Creek site is located in a prominent clearing on the banks of the Porcupine River within a mile of the proposed route and is thereby vulnerable to disturbance. The site at Lapierre House and the site seven miles west of the crest of the Richardsons are also archaeologically important.

Land Reserves, Recreational Lands, and Aesthetics. There are many aspects of maintaining natural qualities that have a high intrinsic value to a region: preservation of particularly unique features, minimization of general disturbance of either physical or biological components of the environment, and the location and scale of the disturbance relative to vantage points and to local relief. The opinions of local people have considerable influence on the evaluation of this subjective concern. General considerations for the Interior Route are basically similar to those discussed for the Prime Route, but features unique to this route require particular mention.

Because of the aesthetic, biological, archaeological and cultural attributes of a large part of the northern Yukon, a proposal was submitted to the Government of Canada in 1971 to establish nine

million acres as an Arctic Wildlife Range. The proposal is still pending. The Porcupine, Bell and Little Bell rivers form the southern boundary of the proposed range; the Beaufort Sea coast forms the northern boundary. Thus, for 117 miles west of the Bell River the Interior Route lies within the boundaries of the proposed Range. Proponents of the Range propose that a management authority would determine the particular conditions under which a pipeline could cross the Range and associated land-use exercises take place.

Consistent with one of the primary purposes of the proposed Arctic Wildlife Range are proposals under the International Biological Programme to give some degree of environmental protection to areas having special ecological significance. The only site being considered that lies near the Interior Route is the Old Crow Basin, which the proposed route skirts on the south side.

The Interior Route passes close to areas that, in addition to being important biologically, are sufficiently unique solely from a landscape point of view that they should be afforded some degree of protection from land-use activities. The Old Crow Flats, a roughly circular lake-studded lowland about 75 miles in diameter, is such an area. The Flats lie just north of the proposed alignment in the nonglaciated part of the Yukon and are surrounded by mountain ranges and low bedrock ridges. They host a rich variety of small furbearers and waterfowl that results in the Flats being an important hunting and trapping area for native people from Old Crow village.

A second such area lies west of Caribou Bar Creek in the Old Crow Range where granite hilltops are deeply weathered and are locally surmounted by spectacular abrupt pillars, called "tors", that have resisted weathering and erosion, and that stand 40 to 50 feet high (Hughes et al., 1973). These are possibly the largest tors in existence. These tors deserve protection from destruction or modification by land-use activities.

Biological Environment

Vegetation. The Interior Route lies only 20 to 30 miles north of the southern limit of continuous permafrost as mapped by Brown (1967), and the vegetative cover plays an important role in thermal insulation of the frozen ground. The dense ground cover of moss and lichen is an important component of this insulative cover, perhaps relatively more important than the sparse tree cover.

The Applicant proposes to clear the right-of-way during the winter of 1977-78 and construct the pipeline during the following winter. Clearing procedures and environmental concerns arising from them are the same as those discussed for the Prime Route. No information exists to suggest that there might be significant risks of loss of critical habitats or of rare and endangered plant species.

Fish. The concern for fish extends necessarily to a concern for the health of the entire aquatic ecosystem upon which fish depend. In the area traversed by the Interior Route, these concerns, of international as well as local importance, involve maintenance of fish resources for local, commercial and recreational use.

Unlike the coastal part of the Prime Route, the entire Yukon segment of the Interior Route lies within the drainage basin of a single river system, the west-flowing Porcupine which is a tributary of the Yukon River. Activities in the upper reaches of even the smallest stream could affect fish migration routes and spawning areas over a wide area in the Yukon and Alaska. Thus it is particularly important that contingency plans be developed to cope with a spill of fuel oil or toxic mat-

erials into the drainage system. International populations of adult chum, coho, and chinook salmon migrate up the Purcupine River from Alaska in the fall, and juveniles migrate downstream in the spring. Most spawn in the Fishing Branch and Miner rivers, approximately 80 miles south of the proposed pipeline route, although some may spawn in the mainstem of the Porcupine. Moreover, considerable year-round domestic use is made of fish by the native population at Old Crow village. Traditional fishing sites are widely distributed. Most recently used sites are near the village, on the mainstem of the Porcupine and on the Old Crow River, although fishing is also carried out on the Porcupine for several miles upstream from the village (Stager, 1974). All of these sites are downstream from pipeline crossings and are therefore subject to impact from pipeline-related activity.

The proposed Interior pipeline route crosses many small streams which, although they are important as spawning and rearing areas in summer, freeze to the bottom in winter. Pipeline crossings of such streams would pose little threat to the fish resource, provided that siltation is adequately controlled and that the bed of the river is restored to a condition similar to its natural state. The presence or absence of water beneath winter river ice is, however, a variable feature that cannot always be appreciated in a one-year survey. It is dependent upon local water depth where the survey was taken, whether in a pool or a riffle, and upon the severity of the winter. The latter factor alone accounted for an approximate two-fold variation in winter-ice thickness in the Yukon between 1973 and 1974. Water beneath ice, even in isolated pockets, could be connected with a subchannel groundwater flow and be a suitable overwintering site for fish and benthic organisms. For these reasons, minor relocation of crossings to coincide with riffles, which tend to be more frequently frozen to the bottom in winter, would reduce the potential for impact on aquatic organisms. Likewise, crossings made in late winter would be most likely to find the stream frozen to the bottom.

Crossings of larger rivers are characterized by winter flow, either below ice or in open water. Risks of siltation and spill of toxic substances pose hazards to fish, both at the crossing site and farther downstream in the Porcupine drainage system. Although the Applicant reports no winter flow at the crossing site of the Old Crow River, the important domestic fisheries immediately downstream make it desirable that the crossing be made in late winter to ensure that local winter-channel and downstream fish migrations have ceased.

Four preferred borrow sites along the Interior Route are located in active river beds. These could pose a hazard to overwintering fish if winter flow is present. A case in point is the Driftwood River where winter flow of well oxygenated water has been observed. In this case, borrow could be removed from the high terrace on the west side of the river with considerably less risk to the fish resources.

Some local problems are posed by the occurrence of open water in winter furnishing a suitable habitat for fish. For about eight miles west of the crest of the Richardsons the route lies in the valley of the headwaters of the Rat River. After crossing the main north fork, the route crosses the east fork to compressor station IA-10 and then crosses back again to the other side. Van Everdingen (1974) has mapped the widespread occurrence of aufeis, springs and open winter water in all forks of the Rat River within 12 miles of the crest of the Richardsons. The water is well oxygenated and has a high potential for overwintering of fish and for a reservoir of benthic organisms that may be important to the health of the aquatic ecosystem downstream. It would be desirable for the route and compressor station to be located entirely north of

the east fork of the upper Rat River, so as to avoid two crossings of this sensitive stream.

East of the Richardsons, the most important area is Stony Creek, crossed by the permanent road to the Dempster Highway. A wide variety of fish use this creek during the summer. Details of this crossing have not been supplied by the Applicant. A culvert installation would have to be carefully designed to ensure the free passage of fish.

Birds. The principal ornithological concerns along the Interior Route involve raptors and waterfowl. The proposed route passes through, or close to, important habitat for each. Permanent facilities and activities, such as compressor stations, airstrips and route monitoring by aircraft, will pose the greatest threat to these birds.

The Applicant has noted, on the Corridor Wildlife Map Series, the importance to raptors of extensive areas along the Interior Route. Included are the north flank of the Old Crow Range, the Old Crow Flats and the high bluffs adjacent to the Porcupine River. Nevertheless, approximately 70 miles of the proposed route, including two compressor stations, pass through these areas. Risks to raptors could be minimized in two ways: careful scheduling and control of construction and maintenance activities, and minor route relocations (*see* topic "Endangered Birds of Prey"). As an example regarding the latter point, it has been indicated above that relocation of the route south of Old Crow Flats even farther south to the low drainage divide between the Flats and the Porcupine River would be desirable for reasons of terrain stability. Such a relocation would also avoid about 25 miles of important raptor habitat and would move compressor station IA-08 to a less sensitive position relative to raptors.

The Applicant has recognized the importance of lake bodies as breeding, moulting and staging areas for waterfowl. By far the most significant area along the Interior Route in this regard, in terms of both ecology and domestic utilization, is Old Crow Flats. Relocation of the route and station IA-08, as discussed above, would reduce the degree of disturbance to waterfowl in this area.

Geotechnical advantages derived from avoiding ice-rich sediments in areas of thermokarst depressions along the route have been mentioned above. All these areas have lakes used by waterfowl. Risks of siltation in these lakes as well as noise disturbance from the surveillance activity along the route would be decreased by keeping away from these lake areas.

Mammals. Mammals that may be encountered along the Interior Route include caribou, Dall's sheep grizzly bear and moose, in addition to smaller furbearers such as beaver, muskrat, marten, fox, lynx, mink and wolf. Only the potential impacts on caribou, grizzly bear and Dall's sheep are considered here.

The Porcupine caribou herd is of international significance owing to its movements between the Yukon and Alaska. Migration patterns and some wintering ranges which tend to vary somewhat from year to year may be affected by pipeline-related activities. In general, spring migration is northward, across the Interior Route, to calving areas on the North Slope. Migrating caribou may reach the pipeline route by mid-April. During the summer, the caribou move southward from the coastal area into the Porcupine drainage basin, entering it near the headwaters of the Bell and Driftwood rivers, then move westward into Alaska through Old Crow Flats and across the north flank of the Old Crow Range. In the fall, most caribou migrate south to their traditional wintering range in the upper Peel River basin,

although small populations may over-winter on the east slope of the Richardsons and in the Porcupine River valley near the proposed Interior Route.

The principal interaction of pipeline pre-construction activities with caribou are expected to involve:

(i) truck movement on the Dempster Highway and on the permanent access road from the Highway at times when caribou are migrating through these areas, and

(ii) local contact between overwintering caribou and various pipeline activities at facilities and borrow sites, on the right-of-way, and along winter roads.

The section of this report dealing with the Porcupine caribou herd along the Prime Route provides a review of concerns over potential caribou-pipeline interactions that are also relevant to the Interior Route. These include aircraft altitude, compressor noise, construction noise, habitat loss from fire, and contingency measures when construction activity conflicts with caribou migration.

In addition, as noted by the Applicant, there is a concern that caribou will preferentially move along the pipeline right-of-way and roads, thus departing from their normal migration path and increasing the potential for erosion and permafrost disturbance. These effects could be a particular problem at lower altitudes along the Interior Route where the right-of-way and the access roads will form a cleared path through the trees. They are most likely to occur in August when westward movement of the herd is nearly parallel to the route and when the ground surface is particularly susceptible to disturbance. In some areas where this problem could be serious, a series of deflection fences across the right-of-way might discourage use of the alignment for migration.

The entire Interior Route is considered to be good to excellent habitat for grizzly bears. Important elements of this habitat are den sites which tend to be on steep slopes and stream banks. Some are used for many years. The Applicant has noted that particular care would be taken to avoid den sites, and that winter construction when the bears are hibernating would minimize impact on their behavioral patterns. Summer activities would have to be monitored very carefully to minimize the attraction of garbage and camp kitchens, and contingency plans for coping with bear encounters would be needed.

The Interior Route skirts the southern edge of Dall's sheep range in the Richardsons (*see* topic "Dall's Sheep"). No impact on Dall's sheep is expected here provided that overflights of their nearby range are avoided.

Highlights

1. Much of the proposed Interior Route in the Yukon Territory crosses an unglaciated landscape that is characterized by deeply weathered bedrock, colluvium-mantled upper slopes, and silt-filled valleys. Farther east it crosses the Richardson Mountains and onto the till-covered slopes of the Peel Plateau and Peel Plain. The entire route is underlain by permafrost. In the unglaciated region, ice content in the soil materials beneath the ground surface generally increases downslope as they become finer-grained and better sorted. The potential for terrain instability and disruption of surface drainage is less on drainage divides than on slopes or in valleys. Potential impact of the route on the environment could be lessened considerably by several relatively minor relocations of the alignment to take advantage of terrain character.

2. Because of the probable antiquity of archaeological sites in the northern Yukon and because the potential for discovery of new sites is high, it is particularly important to provide for a thorough survey and salvage operation to accompany construction activities.

3. The regional and international importance of the Porcupine River as a migration route for fish, including chum, coho and chinook salmon, make it particularly important that siltation be kept at a low level and contingency plans be developed to cope with the release of toxic materials into the drainage system.

4. Numerous traditional domestic fishing sites on the Porcupine River are downstream from pipeline crossings and are therefore subject to impact from pipeline-related activity.

5. The proposed Interior Route passes through approximately 70 miles of important raptor habitat. Minor route relocations, scheduling adjustments and monitoring of pipeline activities would serve to limit the disturbance of these birds.

6. Parts of the proposed Interior Route are usually occupied seasonally three times by the Porcupine caribou herd: during spring migration northward across the route, during summer movements westward along the route, and during fall migration southward across the route. There is some potential for the right-of-way and roads to be used by the caribou during the summer migration; this could lead to undesirable deflection of the herd, and to erosion problems. Additional concerns relate to trucking on the Dempster Highway and access roads, localized interaction with winter construction activities, aircraft flying height, compressor noise, habitat loss from fire, and contingency measures when construction conflicts with caribou migration.

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11.3 THE INTERIOR ROUTE, SOCIO-ECONOMIC IMPLICATIONS

The only community that would be affected in a direct manner by the location of the Interior Route would be Old Crow in the northern Yukon, a Loucheux (Kutchin) Indian village of some 200 people located on the north bank of the Porcupine River at its confluence with Old Crow River. A description of this community and its economic base is contained in the chapter of this report entitled "Local Impact Analysis".

The Interior Route would pass about eight miles north of Old Crow, and south of the Old Crow Flats. The settlement would likely serve as a staging area and transportation centre for pipeline construction since it already has a 5,000-foot airstrip. A winter road would be built to connect the settlement to the winter road connecting the pipeline with the Dempster Highway. A construction camp and materials stockpile would be located at Mile Post 335 of the right-of-way and 240,000 cu yd of fill material would be required to build this site. A source for this material which apparently would not conflict with future community requirements has been indicated by the Applicant.

A block valve and helipad would be located at Mile Post 324, west of the camp and across the Old Crow River. The amount of borrow required for this and its possible source has not been indicated. Also north of the settlement, at Mile Post 325 would be a 60-ft communications tower and helipad. Two thousand cu yd of borrow would be required for this, and again there are no indications of source.

There would be a compressor station, communications tower, and 2,400-ft airstrip at Mile Post 347. This would require 665,000 cu yd of borrow for which a source is indicated. Logistic activity, site preparation and removal of borrow materials, plus work associated with pipeline construction is scheduled to take place over two winter seasons. Completion of the measuring station (1A-07) west of the settlement would not proceed simultaneously with construction of the Interior Route because these facilities are not required until the fifth pipeline operating year (Sect. 14.c. 1.10). There should, in sum, be considerable seasonal work for Old Crow residents for two or three years, with the possibility of a further two seasons of work later. The Applicant's present plans call for the operations phase crews that would monitor and maintain the pipeline facilities near Old Crow to be located in Inuvik.

During the logistics and construction phases, there would be considerable interaction between pipeline workers and the village population because of passenger and freight planes using the community airstrip, and also because of the winter road connection to the right-of-way. During both construction and operation, the right-of-way would be travelled by residents to reach Old Crow Flats to the north. Moreover, the pipeline is located along caribou migration routes (particularly the fall migration) and caribou could follow the right-of-way. This could perhaps be a predisposing factor in the depletion of some sub-herds. Any negative impact on accessible caribou herds could work a hardship on the people of Old Crow. One source indicates that the community took about 600 caribou in 1972, and that 53 per cent of its total income (both cash and in kind) derived from local fish and wildlife resources that year (Gemini North, Vol. VII, p.69). The community is still very much dependent on its local fish and mammal resources.

The possible impact of the Interior Route on the community of Old Crow was recently studied by

Stager.* He describes Old Crow as a community that is "not yet completely caught up in a head-long and uncontrolled reach for the new material world...," and is "...trying very hard to move to the future along a course the people themselves wish to choose" (p.204).

Stager suggests that while the proposed pipeline could be economically beneficial to Old Crow residents through raising employment and local cash flow, it could also be socially damaging by reducing the prevailing interdependence among community members that is so much a part of the character of the village. He indicates that many people in the community feel that things would be permanently changed by pipeline construction in their locality and that the community is opposed to pipeline construction along the Interior Route (pp.204-207).

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*Stager, J.K., 1974. "Old Crow, Yukon and the Proposed Northern Gas Pipeline", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 74-21.

11.4 COMPARISON OF PRIME (COASTAL) ROUTE AND INTERIOR ROUTE

Introduction

The Expanded Guidelines for Northern Pipeline stipulate that the Applicant must provide with his application a "...comparison of the Applicant's proposed route with alternative pipeline routes, in terms of environmental and social factors as well as technical and cost consideration..." (Corridor Guideline 3-iii). The Applicant has provided such a comparison (Sects. 14.e.1.2, 14.e.1.7, and 14.e.1.9).

Herein the Assessment Group focuses on a comparison of the Prime (Coastal) Route and the Interior Route over only the Canadian portions of these alternatives and only where the proposed alignments differ, i.e. between the Alaska-Yukon border and the west bank of the Peel River. Furthermore, this section examines the comparison only on environmental and socio-economic grounds. No more than those technical elements that have environmental and socio-economic implications are considered.

Part of the Applicant's comparison is based upon consideration of estimated capital and operating costs, which are not considered in this section, and considerations of certain factors are averaged over the whole alternative, i.e. Canada and United States combined, without discriminating between the two national segments. Thus the bases of the comparison used in this section are somewhat different from those used by the Applicant, and they lead to somewhat different conclusions.

Specific attributes of the Canadian portion of both the Prime (Coastal) Route and the Interior Route are treated elsewhere in this report. This section deals on a general level with the entire range of environmental and socio-economic concerns and attempts to highlight those factors that are of unequal importance for the two alternatives.

Prime (Coastal) Route

The proposed alignment enters the Yukon from Alaska at a point on the coastal plain north of the British Mountains and four to five miles south of the Beaufort Sea coast. For the next 145 miles it follows the coastal plain eastward and southeastward at distances of two to twelve miles inland from the coast. The route skirts the north end of the Richardson Mountains at the western edge of the Mackenzie River Delta and goes southward for about 80 miles on the narrow alluvial fans between the Mackenzie Delta and the Richardson Mountains before rounding the southern end of the Delta and reaching the Peel River. Throughout its length, the proposed right-of-way is below an altitude of 650 feet above sea level.

Interior Route

The proposed alignment enters the Yukon from Alaska south of the British Mountains, approximately 120 miles south of the Beaufort Sea coast and 1,200 feet above sea level. It extends eastward for 115 miles along the north flank of the Old Crow Range, south of Old Crow Flats, along the north bank of the Porcupine River and across to the Bell River on the west flank of the north-trending Richardson Mountains. Over the next 25 miles the route crosses the Richardsons via the valley of the west-flowing Rat River and via a pass at an altitude of 2,680 feet, before descending the gentle east slope for about 35 miles to the Peel River near sea level.

Applicant's Comparison

The Applicant summarizes his preference for the Prime Route over the Interior Route with the following arguments (Sect. 14.e.1.9, p.2):

(i) the Interior Route is longer and crosses two mountain ranges, making it more expensive to construct;

(ii) the Prime Route is closer to areas with a high potential for future gas supply, resulting in less expensive and disruptive feeder lines as future supplies are brought on stream;

(iii) the Prime Route would have the least adverse effect on wildlife, soil, and vegetation because it is shorter and because it traverses less productive terrain than does the Interior Route; and

(iv) the Prime Route and Interior Routes do not differ significantly in local socio-economic terms and in neither case would adverse effects be expected.

In analysing the Applicant's preference for the Prime Route, the Assessment Group notes the following.

(i) From a purely Canadian point of view, this point of comparison is reversed in that the Canadian segment of the Interior Route is shorter than the Prime Route and requires that only one mountain range be crossed.

(ii) The point relating to proximity of the Prime Route to areas of potential future gas supply is accepted, although the proximity of the Interior Route to the Eagle Plains area is worthy of note.

(iii) The Applicant's preference for the Prime Route on environmental grounds involves data from Alaska as well as Canada, and does not necessarily coincide with a Canadian position. On the other hand, the Assessment Group considers that the Applicant's statement is an over-simplification of the bases of comparison of potential interactions between pipeline and environment. Route length, although a factor, is not the principal factor.

(iv) From a purely Canadian point of view, the Applicant's fourth point does not recognize the potential effects of a pipeline along the Interior Route on the people of Old Crow or the point of view of Old Crow residents.

Environmental Comparison

Technical Elements and Schedules

Permanent and temporary features of the proposed pipeline alternatives that have environmental and socio-economic implications are compared in the table that follows.

Permanent elements of the pipeline have a greater potential for environmental disruption along the Prime Route than along the Interior Route. Included in this category are route length, number of compressor stations, communications towers, airfields and helipads. Requirements for land and for borrow materials are also greater.

Temporary pipeline facilities, on the other hand,

have a greater potential for environmental disruption along the Interior Route than along the Prime Route. Of principal concern in this report are the 120 miles of temporary (winter) road connecting the Dempster Highway with Old Crow and the 50 miles connecting the Highway with Lapierre House. The emphasis on roads for the Interior Route and wharves for the Prime Route reflects the necessity for land access to the Interior Route whereas water access is available for the Prime Route. These differences in access extend, of course, to maintenance and abandonment practices as well. The potential for environmental disruption by land-based activity is judged to be greater than that for water-based activity, particularly in view of the possibility that urgent repair operations may require movement of heavy machinery and supplies to a problem area during the summer season.

Points of Comparison - Technical Elements

(Includes only the Canadian portion of the routes north and west of the Peel River)

1. Permanent Features:	Interior Route	Prime Route
Length (miles)	178	235
Compressor stations	4	5
Measurement stations	1	1*
Communications sites	9	11
New airstrips: 2,400 ft	2	3
6,000 ft	1	2
Helipads	10	13
Permanent road miles	24	12
Land use requirement (acres)	3,534	4,605
Total borrow required (cu yd)	4,600,000	5,700,000
2. Temporary Features:		
Temporary road miles	186	33
Winter trail miles	31	23
Wharves	1	5

*This measurement station is located at a compressor station site.

Those portions of rights-of-way for both routes that require clearing would be cleared in the winter of 1977-78; both routes are scheduled for construction the following winter. Chilled gas is scheduled to move along either route in the spring following completion of construction. Because of its additional length, the Prime Route would require one more construction spread than would the Interior Route.

Staging of supplies, as noted above, is very different for the two routes. Except for 20 miles of pipe that reaches the Interior Route by barge on the Peel River, all pipe is delivered during the winter by road from the Dempster Highway. The Prime Route makes extensive use of five wharves to deliver the pipe during the summer preceding construction. The pipe is moved along temporary roads to the right-of-way during the winter.

Physical Environment

Terrain. The Applicant concludes (Sect. 14.e.1. 2.1.4) that the principal geotechnical differences between the alternative routes are:

(i) that the large amount of bedrock encountered along the Interior Route will require costly ditching procedures; and,

(ii) that relatively high relief along the Interior Route will result in the necessity for more erosion control and slope stabilization measures here than along the Prime Route.

These general arguments are accepted, although there are other aspects of the terrain that also set the alternatives apart.

First, the average ice contents of the unconsolidated soil materials in which the pipe will be

buried are considerably higher along the Prime Route than along the Interior Route. Ice is in the form of massive icy beds and ice dispersed in sediment. Even with careful route selection the potential for terrain-instability problems due to excess ground ice is greater along the Prime Route than it is along the Interior Route. This potential for terrain instability becomes much greater if the general route is considered as a possible corridor for a hot oil line in the future. The requirement for more drill holes to characterize the distribution of excess ice in the ground prior to final routing is greater along the Prime Route.

Both the Prime and Interior routes could be significantly improved by relatively minor relocations of the alignments and associated facilities to locations of lower erosion potential. In the preceding section (The Interior Route) the routing principle was developed for the Interior Route that, because of the pattern of distribution of excess ice in the surface sediments, terrain instability would be minimized if the route followed the drainage divides that roughly parallel the alignment. This is not the case for the Prime Route where the hill tops and hill slopes are commonly underlain by potentially unstable ice-rich silt. Here, the best routing principle would be to avoid the soils with most ice and steeper slopes by keeping to the low ground between hills.

Relationship of the Prime and Interior routes to the regional drainage basins is considerably different. The Prime Route trends almost directly across a relatively large number of independent drainage basins in which the streams rise in the mountains and run northward to the Beaufort Sea or eastward to the Mackenzie River Delta. The route is not confined to any one stream valley for very far. The proposed route crosses the streams relatively low in the drainage basin, thereby minimizing the area in the drainage basin subject to downstream siltation or spill of toxic material. Advantages are that the potential for serious disturbance to the resources in any one stream is minimized. However, the trend of the route across the associated minor drainage paths means that, on the average, more berm breaks will be necessary to maintain natural surface drainage. Also, the proximity of the route to the sea increases the potential for a pollutant transported downstream to reach the sea.

Approximately 140 of the 178 miles of the Interior Route, on the other hand, lie within the large west-flowing Porcupine River drainage basin of the Yukon. East of the Richardson Mountains, streams flow eastward to the Peel River or to the Mackenzie River Delta. The Interior Route crosses numerous tributaries to the Porcupine, but over much of its length it follows close to the mainstem of the Porcupine, and in the Richardsons it lies for several miles in the valley bottom of the west-flowing Rat River. The route crosses the streams relatively high in their drainage basins. The risks to the streams posed by siltation or spill of toxic material are therefore relatively greater for the Interior Route than for the Prime Route. An added complication is that any disruptive element that could be transported downstream in the Porcupine basin would be carried into Alaska and into the Yukon River system there.

Several factors contribute to the potential for terrain instability in the vicinity of a stream crossing. Factors such as "design" flood, vertical and lateral stability of the channel, position of the channel relative to valley walls, height

and steepness of valley walls, and material in the valley sides must all be considered. A qualitative assessment of these factors indicates that the Prime Route involves about twice as many "sensitive" crossings as does the Interior Route. Particularly sensitive due to high, steep and potentially unstable valley sides are the Blow and Fish rivers and an unnamed river between them (at Milepost 331.6 on the Prime Route). The Firth and Blow rivers, both on the Prime Route, each have design discharges an order of magnitude above any stream on the Interior Route.

In summary, the principal terrain factors that give the Prime Route environmental advantages over the Interior Route are:

(i) relatively lower relief resulting in locally more stable slopes and less severe erosion problems; and

(ii) rivers being crossed relatively lower in the drainage basins, thereby minimizing the area in the drainage basin subject to downstream siltation or spill of toxic material.

The principal terrain factors that give the Interior Route environmental advantages over the Prime Route are:

(i) ice contents in unconsolidated sediments are considerably lower along the Interior Route, thereby reducing the potential for erosion and subsidence, particularly if a hot oil pipeline is eventually located nearby;

(ii) risks of pollutants reaching the sea, either during staging operations or due to downstream transportation of a pollutant are less; and,

(iii) stream crossings are fewer and have less potential for terrain instability.

Seismicity. The Applicant has noted that earthquakes up to magnitudes of 6.5 on the Richter scale have been recorded since 1940 within a few miles of where the proposed Interior Route crosses the Richardson Mountains. Risks to a pipeline along the Interior Route have been assessed in the preceding section and have been judged to be small. The Prime Route approaches this seismically active zone from the north before turning eastward to the Peel River. Less of the Prime Route is near the seismically active zone than is the Interior Route. Furthermore, the Prime Route alignment is parallel to regional faults that may be activated by an earthquake, whereas the Interior Route is transverse to these faults. In the event of an earthquake, the potential for damage to a pipeline is considered to be greater along the Interior Route than along the Prime Route, although the relative environmental importance of this is judged to be small.

Archaeology. Owing to the antiquity of artifacts that have been discovered along the Interior Route in the northern Yukon, this route is considered to be archaeologically the most important of all regions proposed by the Applicant for potential pipeline sites.

The potential for discovering new sites along both routes is high. In addition, some known sites along each route are considered sufficiently important that every effort should be made not to disturb them by pipeline-related activities. These include the Klo-kut and Old Chief sites along the Interior Route, and the numerous sites on the east bank of the Firth River near the proposed Prime Route in the vicinity of Engigstciak.

Attitudes toward the effects of a pipeline

alignment passing through potentially important archaeological areas are ambivalent. The prospects of encountering and partially destroying an archaeological site must be weighed against the likelihood that many new sites will be discovered due to pipeline-related activities. Consequently, although there are archaeological distinctions between the two alternatives, they do not lead to a preference for one route over the other.

Land Reserves, Recreational Lands, and Aesthetics. Several land reserves have been proposed for the northern Yukon. The proposal affecting the largest area is that for a Canadian Arctic Wildlife Range. The proposed range includes that portion of the Prime Route, 134 miles in length, that lies in the Yukon, and that portion of the Interior Route, 117 miles in length, situated west of the Bell River. It includes the islands and spits located off the Yukon north coast. The proponents wish this area of 9 million acres to be established as a protected wilderness that would adjoin the Arctic Wildlife Range of similar size established in Alaska in 1960. The proposal would not prohibit development, but controls and stipulations would be particularly strict.

Proposals are being prepared under the International Biological Programme to give some degree of environmental protection to areas having special ecological significance. In the northern Yukon, restricted areas of particular ecological interest to the IBP exist within those regions that have not been glaciated. Unglaciated areas occur along 145 miles of the Interior Route and along 40 miles of the Prime Route.

The two route alternatives may also be compared on the basis of land use and traditional values to local residents. The principal concern here surrounds the population of Old Crow village near the Interior Route, and their extensive use of Old Crow Flats and the Porcupine River Valley as hunting, fishing and trapping areas. Less use has traditionally been made of areas along the Prime Route, although domestic use of the fish of some rivers such as the east-flowing Rat River constitute local exceptions.

Biological Environment

Vegetation. Two main aspects of the destruction of natural vegetation along the rights-of-way should be considered: (a) the loss of timber, wildlife habitat, and rare and endangered plant species; and (b) the roles played by vegetation in terrain stability, such as the resistance offered to soil erosion due to running water, and that due to the insulating effect on the underlying permafrost.

The first consideration is regarded as being of only minor importance along the Interior Route and Prime Route alternatives. More timber will have to be cleared for the Interior Route option than for the Prime Route, particularly along the 170 miles of temporary roads linking the Dempster Highway to the Interior Route. Along the Interior Route itself, trees are common only below about 1,200 feet. The Prime Route will require clearing of timber over only 58 miles, along the west side of the Mackenzie delta. Few of the stands encountered along either route contain merchantable timber. The area lost to wildlife habitat due to destruction of vegetation is 30 per cent greater along the Prime Route (*see* table, Land-use requirement), but is considered negligible in each case. There is no evidence to suggest significant risk to rare and endangered plant species.

The resistance offered by the surface organic layer to soil erosion due to running water is important, but probably equally so along both routes. The insulating effect of vegetation and of the surface organic layer is important along

both route alternatives because both lie within the zone of continuous permafrost as designated by Brown (1967). However, vegetative cover plays a progressively more important role in keeping the permafrost frozen as mean summer temperatures rise at progressively more southern localities. For this reason, destruction of the vegetative cover along the Interior Route could have a more pronounced effect on degradation of the permafrost than it could along the Prime Route. It is also along the more heavily vegetated Interior Route that risks of destruction of this insulating layer by forest fires are higher.

In summary, although clearing of vegetation along the rights-of-way would have a minor overall environmental effect along either route, the effects along the Prime Route would be less severe.

Fish. Relative advantages of the Interior or Prime routes with respect to the fish resource can be considered in two categories:

(i) importance of the fish resource for commercial, domestic, or recreational purposes; and,

(ii) risks that the pipeline-related activities have for the aquatic ecosystem upon which the fish depend.

Uses of the fish resource for domestic and recreational purposes are much greater along the Interior Route. Considerable year-round domestic use is made of fish by the native population at Old Crow village. Most of their traditional fishing sites are along the Porcupine River; all are downstream from proposed pipeline crossings and are therefore subject to impact from pipeline-related activity. In addition, an important international salmon run utilizes the Porcupine River in the spring and fall. Because the entire Yukon portion of the Interior Route lies within the Porcupine basin, siltation or spill of toxic materials constitutes an appreciable risk to the important fish resources there. Traditional fishing sites on the north Yukon slope are fewer and are not located close to crossings proposed for the Prime Route. The east-flowing Rat River, however, is crossed by the Prime Route. This river has been reported to have the only known char run in the Mackenzie Delta area, and it receives extensive domestic use by native people. If the Prime Route is used, particular care would have to be taken to minimize disruption of this fish resource, particularly in view of the Applicant's proposal to extract large quantities of gravel from the active river plain.

Several features of the proposals along both routes carry some risk for the general health of the aquatic ecosystem. These features can be summarized in terms of whether they lead to a preference for one route over the other.

Features that constitute a relative advantage for the Prime Route from the point of view of fish resources are as follows.

(i) As was observed in the preceding discussion of terrain factors, rivers along the Prime Route are generally crossed lower in the drainage basin, than are rivers along the Interior Route, thereby minimizing the areas in the Prime Route drainage basins that are subject to downstream siltation or spill of toxic material.

(ii) Over much of its length the proposed Interior Route follows close to the Porcupine and west-flowing Rat rivers, thereby consituting considerable risk

to the important fish habitats there.

(iii) Although areas of aufeis development are present on the rivers of the western Yukon coastal plain downstream from the proposed pipeline crossings, most fish overwintering areas and groundwater sources are upstream from the crossings (Steigenberger *et al.*, 1974). It is believed, however, that along the Interior Route large numbers of fish overwinter downstream from the pipeline crossing site.

Features that constitute a relative advantage for the Interior Route from the point of view of fish resources are as follows.

(i) Stream crossings on the Prime Route are about twice as numerous as on the Interior Route and are more subject to terrain instability.

(ii) A number of small lakes that are important overwintering and spawning areas for grayling and lake trout occur close to the Prime Route in the Yukon; no lakes of similar importance lie close to the Interior Route.

(iii) Of 18 preferred borrow sites designated along the Prime Route, 10 are in active river plains and could pose a siltation hazard to the fish resource; only 4 out of 14 preferred borrow sites designated along the Interior Route are in active river plains; this difference could be modified, however, by changes in pit location.

(iv) Due to a shorter and colder summer season on the north slope, ecosystems along the Prime Route are believed to be less productive and more fragile, in the sense that they are less able to recover from losses, than are ecosystems along the Interior Route.

In summary, there are a number of environmental concerns relative to the fish resources that favour location of the pipeline along the Prime Route rather than along the Interior Route, and *vice versa*. With respect to fisheries criteria, in view of the importance of present domestic use of the fish along the Interior Route, the importance of the international salmon run on the Porcupine River, and the advantageous position of the proposed Prime Route pipeline crossings with respect to location of important fish habitats, the Prime Route is preferred over the Interior Route.

Birds. The principal bases for comparison of ornithological concerns along the Interior and Prime Routes are the comparative potentials for disruption of raptors on the one hand, and waterfowl and shore birds on the other.

Both routes pass through, or close to, equally important habitat for raptors. The main concerns —distance from nesting sites and scheduling of noisy activities—are the same for the two alternative routes (*see* topic "Endangered Birds of Prey").

The Applicant has noted that the Arctic Coastal Plain, which is traversed by the Prime Route, is one of the most significant waterfowl and shorebird nesting, moulting, staging and migration areas in Alaska and northwest Canada. The Snow goose is one of the more important species in this area. In addition, the Mackenzie Delta is an extremely important habitat for waterfowl. If construction were undertaken along the Prime

Route, environmental concern would centre on two factors:

(i) overflights across the Mackenzie Delta and surveillance and supply flights along the Delta and coastal plain would have a considerable disruptive effect on nesting birds and migration flights; and,

(ii) the extensive barging operations along the coast required prior to construction, and the pipeline-related activities only a short distance up-river from the coast would constitute a considerable risk of harmful pollutants, such as fuel oil, reaching the sea coast.

The only area of comparable concern for waterfowl along the Interior Route is the Old Crow Flats area. The proposed alignment would not require overflights of the Flats, and minor relocation of the alignment would substantially decrease the chances of pollutants being discharged into the Flats.

In summary, the Interior Route would be less disruptive to birds than the Prime Route.

Mammals. A wide range of mammals, including caribou, Dall's sheep, grizzly bears, moose, beaver, muskrat, fox, lynx, mink and wolf, may be encountered along either the Interior or the Prime routes. Of these mammals, the populations of caribou, Dall's sheep and grizzly bears would run the most risk of serious interference by pipeline-related activities. For this reason, the comparison between the route alternatives will be based on consideration of these three mammal types.

The potential for disturbance to the caribou by activities related to the Prime Route has been discussed in detail in the topic "Porcupine Caribou Herd". Because of its migration patterns, this herd is a joint responsibility of both Canada and the United States. The following points could be repeated in summary.

(i) The Prime Route crosses the critically important calving area on the coastal plain. Calves are born from late May to mid-June. Although construction activities would be curtailed at this time of year, borrow-pit blasting and aircraft could be very disruptive.

(ii) Prime Route construction on the east slope of the Richardson Mountains during the winter could displace the herd that overwinters there and upon which nearby native people depend for food.

(iii) The late-spring migration westward along the coastal plain is roughly along the proposed alignment for the Prime Route. Aircraft surveillance during the operational phase of the pipeline would constitute a repeated disturbance to the herd.

(iv) Use of the Dempster Highway as a supply link for the Interior Route has some potential for disturbance of the herd and deflection of its migration path.

The Interior Route is transverse to the northward spring migration and to the southward fall migration and would be expected to have a negligible effect on the herd.

Because the Interior Route skirts past the southern edge of Dall's sheep range, no significant impact on Dall's sheep would result from use of this route. However, significant adverse effects

on Dall's sheep that could result from use of the Prime Route have been discussed in the topic "Dall's Sheep". The main concern centres on the population of Dall's sheep on Mount Goodenough in the northern Richardson Mountains. The proposed alignment passing Mount Goodenough is constrained by the steep mountains on the west and by the Mackenzie Delta on the east. For several miles the alignment is within two miles of important sheep range. The sheep are known to be very sensitive to noise, particularly from aircraft. There is a strong possibility that the sheep could be driven from their traditional wintering and lambing areas, resulting in a high mortality amongst this population.

Grizzly bear range widely over the good to excellent habitat that exists along both the Interior and the Prime routes. The main distinction to be made between the routes is that numerous denning sites occur in the vicinity of the Interior Route, whereas none have been reported from near the Prime Route. The denning sites are, however, easily avoided so there is no strong reason to prefer either route alternative.

In summary, environmental concerns over wildlife, particularly caribou and Dall's sheep, would be greater if the gas pipeline were to follow the Prime Route than if it were to follow the Interior Route.

Socio-Economic Comparison

Two communities would be most directly affected by the choice between the Prime Route and the Interior Route alternative. These are Old Crow in the northern Yukon and Aklavik in the Mackenzie Delta. Apart from these two centres, there are no permanant communities in Canada that could be affected by the rights-of-way of either of the two alternatives. However, two DEW line stations are located in the general vicinity of the Prime Route right-of-way, at Shingle Point and Komakuk Beach. It is unlikely that the functions of these stations would be affected by the pipeline, whichever route was chosen.

Both of the proposed pipeline alternatives would affect Old Crow and Aklavik (and perhaps also some other Mackenzie Delta communities) in two basic ways: one of these would include the employment of local labour, income effects that might result from such employment, use of local facilities for staging or transient passage, some purchase of some local services, etc. The second type of effect would centre on possible disturbances by pipeline construction and operation to the local economy through an interference with the resource base used by Native people in hunting, trapping and fishing.

Either route alternative would affect local employment, income, etc., in both Old Crow and Aklavik. However, the Interior Route would have a much stronger effect on Old Crow than the Prime Route. Access to the pipeline by local people, and to the community by non-resident pipeline workers, could be quite direct. In a similar vein, the Prime Route would have a stronger effect on Aklavik than would the Interior alternative. However, in this case, many people from the community would likely take employment with pipeline construction, oilfield development, oil and gas exploration and other activities regardless of which of the two pipeline alternatives were chosen. In other words, while the choice between the alternative routes is of considerable importance to Old Crow, it is probably of somewhat more marginal importance to Aklavik.

With regard to the question of interference with the local resource base, the choice between the two alternatives would also seem to be of more

urgent concern to Old Crow. The Interior Route would lie closer to this community than would the Prime Route to Aklavik and would traverse renewable resource areas that are critical to the local economy of Old Crow. Also, Old Crow residents continue to be more dependent upon hunting, trapping and fishing than residents of Aklavik who have a wider choice of employment. Generally, choice of the Interior alternative would not be beneficial to the continuation of the traditional economy of Old Crow. A recent study by Stager (1974) has indicated that residents of Old Crow are not in favour of a pipeline along the Interior Route.

The traditional resource base of Aklavik would be affected to some degree by a pipeline along the Prime Route. Effects would occur most strongly along the eastern flank of the Richardson Mountains and, to a lesser degree, along the Coastal Plain. Constraints arising out of a pipeline would not only affect Aklavik, but, to a lesser or greater degree, other Delta communities. All things considered however, such affects would probably not be as great as the effects of the Interior alternative on Old Crow.

Highlights

Only those portions of the Interior and Prime routes lying between the Alaska-Yukon border and the west bank of the Peel River have been considered here. Furthermore, the comparison has been based solely on environmental and local socio-economic concerns.

1. Comparison of the Interior Route and Prime Route alternatives based on environmental significance of technical elements of the proposal, terrain factors, seismicity, archaeology, land reserves and aesthetics, vegetation, fish, birds, and mammals does not lead to a unanimous preference for one route over the other.

2. In contrast, because of the location of the settlement of Old Crow adjacent to the Interior Route, this alternative has a substantially greater potential for socio-economic impact than the Prime Route.

3. Although temporary features, such as long access roads, associated with the Interior Route have a higher potential for environmental damage than similar features for the Prime Route, permanent features such as route length and numbers of compressor stations, airstrips, and helipads constitute more of a long-term stress along the Prime Route.

4. Ground-ice contents are substantially lower along the Interior Route, and stream crossings there are fewer and more stable.

5. Risks of pollutants reaching the sea, either from barges used in the staging process or derived from pipeline activities only short distances upriver from the coast, are appreciable in the Prime Route case and negligible for the Interior Route.

6. Seismic risk is somewhat greater along the Interior Route.

7. There is little difference between the alternatives in terms of archaeology, land reserves and aesthetics, or vegetation concerns.

8. In view of the importance of present domestic use of fish along the Interior Route, the importance of the international salmon run on the Porcupine River, and the advantageous position of the proposed Prime Route pipeline crossings with respect to location of important fish habitats, use of the Prime Route would minimize risk to the fish resource.

9. The importance of the Mackenzie Delta and the Arctic Coastal plain as nesting, moulting and staging areas for waterfowl and shorebirds lends an element of concern to the Prime Route that is almost negligible along the Interior Route.

10. The potential for disturbance to both the Porcupine caribou herd and Dall's sheep would be greater for a pipeline along the Prime Route than for one along the Interior Route.

Literature Sources

Brown, R.J.E., 1967. "Permafrost in Canada", Nat. Res. Council Publ. 9769; Geol. Surv. Can. Map 1246A, Ottawa.

Rampton, V.N., 1974. "Terrain Evaluation with Respect to Pipeline Construction, Mackenzie Transportation Corridor: Northern part, Lat. 68°N. to Coast", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 73-47.

Stager, J.K., 1974. "Old Crow, Y.T., and the Proposed Northern Gas Pipeline", prepared for the Task Force on Northern Oil Development, Ottawa, Report 74-21.

Steigenberger, L.W., *et al.*, 1974. "Northern Yukon Freshwater Fisheries Studies, 1973", prepared for the Task Force on Northern Oil Development, Ottawa, Rept. 74-20.

REQUESTS FOR SUPPLEMENTARY INFORMATION

These requests for information are designed to elicit from Canadian Arctic Gas Pipeline Limited "further and better particulars" concerning various aspects of the Mackenzie Valley Pipeline project as described in the exhibits accompanying the Application to the Department of Indian and Northern Affairs. This information is required to assist in review and appraisal of the socio-economic and environmental implications of the Applicant's proposal insofar as they apply to the Northwst Territories and the Yukon Territory, and to facilitate the forthcoming public hearings under the Territorial Lands Act. The requests take into account the environmental and social concerns of the government set out in the Expanded Guidelines for Northern Pipelines as tabled in the House of Commons on June 28, 1972, and each separate request is tied to one or more of the guidelines.

This submission deals with the majority of the subjects for which it is anticipated that supplementary information will be required, but some additional requests for supplementary information will be presented in another submission, or submissions at a later date. In particular, requests relating to certain socio-economic matters have been delayed pending receipt and review of the additional socio-economic volume that the Applicant has indicated will be available during June.

Various environmental concerns are so closely inter-related with engineering aspects of the proposed project that it is essential to review some engineering proposals in order to deal effectively with their environmental implications. For this reason, some of the requests for supplementary information relate primarily to engineering topics.

The present questions are intended to concentrate on information that can be required of the Applicant to assist in review and appraisal of his proposals at the stage of planning represented by his present application and exhibits and at the present stage of the governmental review process. It is recognized that certain project details (for instance detailed engineering design and construction specifications) apply, of necessity, to a later stage, and the present requests for additional information attempt to avoid asking for such details. Thus it will be noted that many of the questions dealing with such matters ask for illustrative examples, typical sites, rationale, and explanations to amplify the Applicant's proposals and to forecast his implementation of them.

No. 1
JOB TRAINING FOR NORTHERN RESIDENTS FOR PRE-CONSTRUCTION AND CONSTRUCTION PHASES

Guideline Reference

Social Guideline 1: "The Applicant must undertake specific programs leading to the employment, at all occupational levels, of residents of the territories - and in particular native people, during the construction and operation of the pipeline. Such programs or projects shall include but not be limited to: advance information on all jobs in a manner that ensures that the information reaches potential workers; skills required for various occupations and anticipated duration of employment; upgrading and skill training; other forms of integrated training that include on-the-job work experience; and counselling for those unfamiliar with industrial jobs or wage style living. All training, orientation and counselling courses will be planned and carried out in co-operation with the various agencies of government responsible for these matters. The pipeline companies shall have particular responsibility for on-the-job work experience."

Background

The Applicant refers to training programs designed to enable northern residents to qualify for employment at all stages of the pipeline project, but most of the information provided relates to training for the operation and maintenance phase. Little information is provided on training for employment during the pre-construction and construction phases except for brief mention of discussions with the Pipeline Contractors Association and unions directed towards on-the-job training and experience for northerners on pipeline construction spreads.

Information Required

The Applicant is asked to provide:

1. Specific additional information on the proposed program of on-the-job training on pipeline construction spreads, including approximate number of northern residents to be trained, jobs they would be trained for, duration and schedule of training, and approach to problems relating to levels of formal education.
2. Similar information concerning other training plans which would enable northern residents to qualify for employment during the pre-construction and construction phases, and which would provide for upgrading of skill levels.

No. 2

JOB BREAKDOWN

Guideline Reference

Social Guideline 1: "The Applicant must undertake specific programs leading to the employment, at all occupational levels, of residents of the territories—and in particular native people, during the construction and operation of the pipeline. Such programs or projects shall include but not be limited to: advance information on all jobs in a manner that ensures that the information reaches potential workers; skills required for various occupations and anticipated duration of employment; upgrading and skill training; other forms of integrated training that include on-the-job work experience; and counselling for those unfamiliar with industrial jobs or wage style living. All training, orientation and counselling courses will be planned and carried out in co-operation with the various agencies of government responsible for these matters. The pipeline companies shall have particular responsibility for on-the-job work experience."

Information Required

1. The Applicant is requested to provide further information on the jobs and work crews involved in the pre-construction and construction phases of the project and on the jobs that could be filled by northern residents, especially native residents. Specifically, he is asked to describe a typical work crew involved in (a) clearing, (b) preparation of airfields and stations, (c) a construction spread; and to include the following information for each of these categories:
   - total number of workers
   - job categories (titles) and skill levels
   - number of workers in each job category and duration of employment
   - number of jobs in each category that could be filled by northern residents.
2. The Applicant is requested to supplement the information he has provided regarding his operations and maintenance personnel by indicating which positions listed in Table 21-2d of Section 13.b (five-year personnel requirements for the Northern Division) could be filled by northern residents in

general and native northerners in particular.

No. 3
JOB INFORMATION AND JOB COUNSELLING, PRE-CONSTRUCTION AND CONSTRUCTION PHASE

Guideline Reference

Social Guideline 1: "The Applicant must undertake specific programs leading to the employment, at all occupational levels, of residents of the territories—and in particular native people, during the construction and operation of the pipeline. Such programs or projects shall include but not be limited to: advance information on all jobs in a manner that ensures that the information reaches potential workers; skills required for various occupations and anticipated duration of employment; upgrading and skill training, other forms of integrated training that include on-the-job work experience; and counselling for those unfamiliar with industrial jobs or wage style living. All training, orientation and counselling courses will be planned and carried out in co-operation with the various agencies of government responsible for these matters. The pipeline companies shall have particular responsibility for on-the-job work experience."

Background

The Applicant has outlined a program of information, recruitment, selection and counselling in connection with the existing training program leading to employment of northern residents during the operations and maintenance phases of the proposed project, but he does not elaborate on the similar program that will be needed, with respect to jobs available during the pre-construction and construction phases.

Information Required

The Applicant is requested to provide specific descriptions of his plans to provide advance information to communities and to government agencies, concerning job opportunities available during the pre-construction and construction phases of the proposed project. He is also asked to provide information concerning the procedures for recruitment, selection and counselling that he would use to facilitate employment of northern residents and especially native people.

No. 4
SPECIAL ARRANGEMENTS FOR EMPLOYMENT OF NATIVE NORTHERN PEOPLE

Guideline Reference

Social guideline 2: "Priority placement in jobs shall be accorded native people of the territories in keeping with the tenor of Arcticle 5 of the International Labour Organization Convention 111, 1958, ratified by Canada, and the government's intent to increase employment opportunities for members of disadvantaged minority groups. During the consultation between government, unions and employers as outlined in the Convention, ways and means will be found to ensure access for these employees into the appropriate union locals and hiring halls where there is a requirement. In addition, in accordance with the principle of employment of local workers which is accepted by organized labour, the Applicant shall comply with the above Convention and employment principles, and co-operate with government's effort to operate an effective recruitment, placement and counselling service."

Social Guideline 3 (in part): "In addition, in situations where special measures are required to ensure the employment of native people as outlined in the International Labour Convention 111, the Applicant shall negotiate special agreements related to the employment of native people, in consultation with the native people and government."

Background

The above guidelines deal with employment practices and agreements relating specifically to native people of the northern territories and are designed to facilitate and ensure employment of native people.

Information Required

The Applicant is asked to respond in as specific terms as possible to the matters relating to employment of native people that are raised by these guidelines. In particular he should indicate how his stated employment policies and procedures for northern residents would meet the special concerns about employment of native northern residents which are expressed in the guidelines.

No. 5
ORIENTATION AND CONSULTATION PROGRAM

Guideline Reference

Social Guideline 3 (in part): "To set up special orientation and consultation machinery to familiarize its staff and employees with the culture and aspirations of native people and of territorial residents generally. Conversely, this orientation and consultation will acquaint employees from the territories with the pipeline industry and the work habits and life style of non-territorial employees. The orientation and consultation activity shall be planned and operated with participation of native people, other northern residents, organized labour, the Applicant and the appropriate governmental agency that will co-ordinate and monitor the various functions performed."

Background

The Applicant indicates his intention, in general, to set up an orientation program for northern and southern workers designed to promote understanding and appreciation of the different cultures and to plan, co-ordinate and monitor the various functions of the orientation and consultation activity in co-operation with the people and agencies concerned. However, the only information presented concerning such a program relates to orientation procedures that the Applicant already has followed in his Northern Training Program.

Information Required

1: The Applicant is asked to provide, in some detail, his proposals regarding the content and methodology of the orientation-consultation program that is a requirement of this Guideline.

2. The Boreal Institute report (Section 14.f, Appendix D, Part II, pp. 90-93) includes discussion of an orientation program designed to ease the problems of northern wives and families relocating in northern communities near the pipeline project. The Applicant is requested to indicate whether he intends to implement such a program and to state his views as to the possibility of providing a related program for the wives and families of southern workers who move to northern communities.

No. 6
LOCAL CONTRACTORS, GOODS AND SERVICES

Guideline Reference

Social Guideline 4: "Contracts and sub-contracts shall be so designed and publicized as to invite and encourage bids from native organizations, settlement councils and local contractors. In addition, the businesses and commercial organizations of the territories shall be invited and encouraged to supply goods and services required for the pipeline development and operation."

Background

The Applicant has agreed in principle that local contractors and suppliers should be encouraged to bid on contracts and sub-contracts and to supply goods and services required for the pipeline project.

Information Required

The Applicant is requested to supply a list of the types of pipeline activities which would be appropriate for local contractors, either as complete contracts or as portions of larger contracts, and to provide a list of the goods and services which he believes could be supplied locally.

No. 7
HUNTING, TRAPPING AND FISHING

Guideline Reference

Social Guideline 5 (in part): "A substantial number of native people depend on trapping and hunting as a principal means of livelihood, and many derive a real satisfaction from being on the land and being master of a familiar environment. Therefore, the pipeline will be constructed, operated and abandoned with minimal interference to traditional trapping, hunting and fishing areas."

Background

The substantial population shifts and increased ease of access which would result, directly or indirectly, from the proposed pipeline project could be expected, over time, to result in changes (increases and decreases) in the various pressures exerted on hunting, trapping and fishing resources in the region traversed by the pipeline route. The Applicant's intention to control and minimize fishing and hunting by personnel at his camps and other facilities is an essential step in attempting to reduce impacts on hunting, trapping and fishing resources. Nevertheless, sufficient concern remains in this regard to require a review of the over-all impacts on renewable resources, and on areas of localized resource use.

Information Required

1. The Applicant is requested to provide a review of the present and traditional use by the native people and other northern residents of hunting, trapping and fishing resources in the project area in relation to the size of these resources, and also the increase or decrease in use of these resources that would take place as a consequence of population changes relating to the pipeline and pipeline-dependent developments; to comment on the capability of these resources to support the expected increases; and to comment on pipeline-induced changes in the return which native people could expect to obtain from hunting, trapping and fishing.

2. The Applicant is requested to mark on his "Alignment Sheets" (and on supplementary photo-mosaic sheets which will be prepared to illustrate facilities outside the area of the "Alignment Sheets"), the location of traplines, trapping areas, hunting areas, fishing areas and camping areas presently or traditionally used by native people, and to indicate the time of year during which they are, or have been, used. The areas and sites to be indicated should include (a) those which are crossed or encroached upon by the Applicant's facilities and activities, (b) those additional sites where the Applicant's activities might have an effect on the resource, land or water utilized by the native people and (c) those addtional sites where the Applicant's facilities and related activities might facilitate access or use by local people.

3. Where the Applicant's right-of-way, access roads or other facilities cross, adjoin, or otherwise affect hunting, trapping, fishing, and camping areas used by local people, the Applicant is asked to identify the nature and timing of pipeline activities that would take place during the same periods as activities of the local people.

No. 8

CLAIMS AND COMPENSATION

Guideline Reference

Social Guideline 6: "Where the construction, operation or abandonment of a pipeline results in loss or damage to the undertakings or property of territorial residents - and native people in particular - then the Applicant shall deal promptly and equitably with all reasonable claims."

Information Required

The Applicant is requested to provide a statement on how the established practices concerning compensation for loss or damage to property or undertakings in other parts of Canada due to pipeline activities would be adapted to cover similar or special situations in the northern territories, including proposed measures to establish uniform and equitable standards of compensation, to receive submissions relating to claims, and for speedy disposition of claims.

No. 9

CONSERVATION OF SCARCE RESOURCES

Guideline Reference

Social Guideline 7 (in part): "In order to ensure that social and economic benefits outweigh the costs, the Applicant shall make a conscious effort to contribute to the social and economic development of the territories. This objective shall have particular relevance regarding: .... preserving scarce resources such as aggregate and forest products required by communities - both present and future demands ..."

Information Required

The Applicant is requested to indicate the approaches he intends to take concerning his use of scarce resources, in relation to needs for conservation of supplies to meet present and future needs of northern communities.

No. 10

PIPELINE EFFECTS ON INDIVIDUAL COMMUNITIES

Social Guideline 5 (in part): "In addition, where the pipeline construction is planned to be located in proximity to a settlement—particularly a native settlement or localized area subject to intensive use, then the location of construction camps, associated activities and the detailed siting of the pipeline will be decided by government after consultation with the Applicant, and the settlement council, or local government body, or the native organization."

Social Guideline 7 (in part): "In order to ensure that the social and economic benefits outweigh the costs, the Applicant shall make a conscious effort to contribute to the social and economic development of the territories. This objective shall have particular relevance regarding; locating permanent infrastructure and maintenance facilities so that their presence will be to the benefit of communities."

Social Guideline 8: "The pipeline construction activity shall be self-sufficient with respect to certain services such as sewer and water, power, roads, fire prevention, recreation services and emergency health services unless there is a prior agreement to the contrary. With respect to other public services that by their nature must remain

under public control such as police protection, base hospitals and like services, there will be early consultation with the appropriate level of government to ensure adequate preparation and continuing liaison during the construction and operation phases to ensure maximum co-ordination and co-operation."

Background

Although the Applicant has provided considerable information concerning his activities in and around communities in the northern territories and on the general effects of his project on the social and economic life of the people of the Territories, more specific information is required in order to identify effects which the pipeline would have on individual communities and settlements.

Information Required

The Applicant is requested to provide a statement concerning the anticipated interaction between the pipeline project and associated developments and the following communities:

Hay River	Fort Good Hope
Fort Simpson	Arctic Red River
Trout Lake	Inuvik
Jean Marie River	Aklavik
Wrigley	Tuktoyaktuk
Fort Providence	Fort McPherson
Norman Wells	Old Crow (Interior Alternate Route)
Fort Franklin	
Fort Norman	

The statement for each community should include information, where relevant, on the following, in as much detail as is possible at the present stage of project planning.

A. Physical equipment, facilities and services:

1. Facilities to be constructed in or near the community such as houses, other buildings, recreation facilities, "utilities", wharves, storage sites, borrow sites, waste disposal sites, roads (see note).

2. Extent of use of existing buildings, facilities, utilities and services within and adjoining the community, particularly government services such as hospitals, schools, etc. and the transportation and communication systems.

3. Nature and volume of demand for goods and services to be purchased from supplies available within the community.

4. Use of local contractors for work within the community and elsewhere; use of outside contractors on projects within or adjacent to the community.

5. Nature and quantity of materials to be stored in and adjacent to the community and duration of storage; nature and quantities of materials to be routed through or close to the community.

6. Routes proposed to provide access from the community to pipeline and related facilities outside the community; routes for transfer of materials within and around the community, from and to wharf, stockpile, fuel storage sites, airport, etc. (see note).

7. Volume of vehicular traffic within and adjoining the community and the kinds of vehicles involved; number of boat and barge landings, number of aircraft flights in and out of the community and adjoining area and the type of aircraft.

Note: Items A - 1 and 6 should be accompanied by a photo-map on the same scale as the "Alignment Sheets" showing routes and location and extent of facilities.

B. Population movements and personnel:

1. Approximate number of people (per month or per season) who would pass through or stop in the community while travelling in connection with the pipeline project and related activities, including aircraft passengers changing planes.

2. Approximate number of community residents who could be employed *in or near* the community on the pipeline project and related activities, including the time of year and duration of employment.

3. Approximate number of community residents who could be employed *away from* the community on the pipeline project and related activities, including the time of year and duration of employment.

4. Approximate number of "in-migrants" who would be resident in or adjacent to the community while employed on the pipeline and related activities, with an indication of the duration of their stay.

No. 11
PIPELINE - COMMUNITY RELATIONSHIPS

Guideline Reference

Social Guideline 7 (in part): In order to ensure that the social and economic benefits outweigh the costs, the Applicant shall make a conscious effort to contribute to the social and economic development of the territories. This objective shall have particular relevance regarding; locating permanent infrastructure and maintenance facilities so that their presence will be to the benefit of communities."

Social Guideline 8: "The pipeline construction activity shall be self-sufficient with respect to certain services such as sewer and water, power, roads, fire prevention, recreation services and emergency health services unless there is a prior agreement to the contrary. With respect to other public services that by their nature must remain under public control such as police protection, base hospitals and like services, there will be early consultation with the appropriate level of government to ensure adequate preparation and continuing liaison during the construction and operation phases to ensure maximum co-ordination and co-operation."

Information Required

1. Where the Applicant proposes to provide new housing, recreation facilities, utilities, etc. for pipeline personnel, in or adjacent to the community, he is asked to provide a timetable for consultation with the community and with appropriate governmental agencies concerning location of, and requirements for, such facilities, in order to ensure appropriate integration with the community as well as to provide sufficient lead time for the preparation of augmented public services resulting from the increased population.

2. The Applicant is asked to indicate ways in which local businesses and enterprises could be assisted to take advantage of opportunities made available by the pipeline project.

3. The Applicant is asked to indicate procedures that he could use to minimize the impact on northern communities of an influx of job-seekers from the south.

4. Where construction camps or other work sites are adjacent to settlements, the Applicant is asked to indicate measures he would apply to minimize possible adverse social and economic effects resulting from interaction between pipeline personnel and settlement residents.

No. 12
WHARF AND STOCKPILE SITES

Guideline Reference
Various Guidelines

Background

The Applicant has provided little information on wharves and adjoining stockpile sites. Maps included with Section 13a show their approximate location but most of them lie outside the boundaries of the "Alignment Sheets". Moreover, it is not apparent how environmental or socio-economic considerations are taken into account in site selection, design, or scheduling.

Information Required

The Applicant is asked to make available:

1. Photo-mosaics, compatible with the "Alignment Sheets", showing the location (and if possible outline) of wharf and wharf-stockpile sites, together with the routes of access roads and location and extent of borrow sites.

2. A general description, with diagrams, of a typical stockpile site and wharf together with an account of the sequence of activities at the site including clearing and related procedures, emplacement of borrow materials, construction of facilities, movement of materials into and out of the site, and rehabilitation of any parts of the site not used during the operational stage of the pipeline. This account should indicate the time of year and duration of the various activities at the site and the number of persons involved in each activity, and should make reference to contingency plans and flooding hazard. The sample site chosen should not be contiguous to a community or utilize pre-existing wharf facilities.

3. A statement indicating the kinds and detail of technical environmental and socio-economic information that the Applicant would expect to obtain and use for detailed site selection and for preparation of site plans.

No. 13
FACILITIES NOT SHOWN ON "ALIGNMENT SHEETS"

Information Required

The Applicant is asked to provide photo-mosaic maps with terrain typing, at the same scale as the "Alignment Sheets" showing location of all his proposed facilities including permanent and temporary roads that lie outside the boundaries of the "Alignment Sheets". This request in part overlaps on the "requests" concerning (a) Borrow Sources, (b) Wharf and Stockpile Sites, and (c) Community Information.

No. 14
GAS AND OIL PIPELINE ROUTES

Guideline Reference

Corridor Guideline 3(i): "In view of the influence of the first trunk pipeline in shaping the transportation corridor system and in moulding the environmental and social future of the region, any applicant to build a first trunk pipeline within any segment of the corridor system oultined in 1. above must provide with his application:

i) assessment of the suitability of the applicant's route for nearby routing of the other pipeline, in terms of the environmental-social and terrain-engineering consequences of the other pipeline and the combined effect of the two pipelines; (fully engineered proposals concerning the other pipeline are not necessarily required);"

Background

The Applicant makes general reference to this guideline but does not provide comments on matters such as the following which would facilitate a review of his routing in terms of the corridor concept.

1. Comment on the suitability of the Applicant's proposed route as the route for a large-diameter oil pipeline in terms of technical constraints (e.g. foundation conditions for a warm pipeline across permafrost areas as different from the chilled gas pipeline) together with identification of any areas where the Applicant's proposed route might not be appropriate for an oil pipeline in this regard.

2. Comment on the suitability of the Applicant's proposed route as the route for a large-diameter oil pipeline in terms of potential environmental effects of the oil pipeline (e.g. oil spill hazard) together with identification of any areas where the Applicant's proposed route might not be suitable for an oil pipeline in this regard.

3. Comment on availability of sources of borrow materials near the Applicant's proposed route that are adequate and suitable to meet not only his needs but also those of a large-diameter oil pipeline without depletion of reserves needed for other purposes, together with identification of locations where shortages might occur.

4. Identification of locations along the Applicant's proposed route where juxtaposition of oil and gas pipelines might be inappropriate because of local topography, foundation conditions, or environmental factors.

5. Comment on any regional socio-economic factors that bear upon the suitability of the Applicant's proposed route as the route for an oil pipeline.

Information Required

The Applicant is asked to respond in greater detail to Corridor Guideline 3(i).

No. 15
LIARD AND MACKENZIE RIVER CROSSINGS

Guideline Reference

Corridor Guideline 2: "To confine the environmental (and social) disturbance arising from pipelines and their construction to a limited area, trunk oil and gas pipelines within the corridors outlined in 1. above are to follow routes that are as close together as is consistent with the differing engineering constraints and environmental hazards of the two types of pipelines, but not so close together as to bring about undesirable environmental interaction between the two lines. The same principle is also to apply where the trunk pipeline route lies parallel and near to a present or proposed highway or other overland communication system."

Corridor Guideline 3(iii): "comparison of the applicant's proposed route with alternative pipeline routes, in terms of environmental and social factors as well as technical and cost considerations; (fully engineered proposals concerning alternative routes are not necessarily required)."

Environmental Guideline 3(c): "design of underground crossings of rivers and streams that could withstand the effects of run-off, bank erosion, meander cutoffs, lateral migration of stream channels, ice jams, and icings, the magnitudes of which should be calculated according to reasonably expected extremes for a particular stream crossing area;"

Background

The proposed route for the pipeline crosses both the Liard River and the Mackenzie River below the Liard River junction. The Liard River doubles the flow of the Mackenzie near Fort Simpson and has a marked influence on the annual flood and spring break-up of the Mackenzie River (Section 14.d.N. 4.3.2). Because of the sequence of spring break-up and run-off, the Mackenzie River is subjected to extensive ice jams and flooding downstream from the Liard River junction (Section 14.d.N.4.3.3).

Information Required.

The Applicant is asked to provide a statement comparing the section of his proposed route involving the Liard and Mackenzie crossings with an alternative route involving a crossing of the Mackenzie upstream from the Liard. The statement should provide the rationale for the choice made.

No. 16
RATIONALE OF LOCATION OF COMPRESSOR SITES

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

also *other environmental guidelines and corridor guideline 3(iii).*

Background

Compressor sites are major foci of activity in the pipeline system. Their location controls location of many other componenets of the system. In this regard, the Applicant indicates (Section 8.a.1.6.1): "Following the hydraulic determination of locations, geotechnical, socio-economic and environmental factors must be reviewed. These include suitable soil types and topography which will allow the station, associated airstrip and connecting road to be constructed in the desired area." However, the Applicant does not describe how these factors were used in reaching decisions on location of compressor sites.

Information Required

The Applicant is requested to illustrate the process of selecting compressor sites using the following 3 stations as specific examples:

1. Compressor Station M02
2. Compressor Station M04
3. Compressor Station M16

In particular the analysis should illustrate the actual amount of flexibility of location that is permitted by the hydraulic calculations.

No. 17
TERRAIN TYPING

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Background

The Applicant states (Section 8.b.1.3.6, p.40) that terrain typing can be applied to "show areas where topography, surface and subsurface materials, erosion, drainage and permafrost will make it necessary to employ special design features" and "to pinpoint areas where environmental disturbance could result during pipeline construction", and is used in "slope stability, buoyance effects, erosion control, and site evaluation studies for compressor stations, airstrips and access roads". However, the Applicant does not provide evaluations of terrain units from a pipeline engineering point of

view, either in the text of his report or in the legend.

Information Required

The Applicant is asked to provide the additional information concerning the mapped terrain units that would permit evaluation of their environmental suitability for pipeline construction and operation. Such information includes (a) physical and engineering properties of materials, (b) quantity, form and distribution of ground ice, and (c) susceptibility to slope failure, erosion and thermokarst subsidence.

No. 18

RIGHT-OF-WAY GRADING AND CUTS IN PERMAFROST

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practices to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Background

In areas of sensitive permafrost requiring "Arctic construction techniques" the Applicant proposes that "filling techniques will be utilized to the greatest extent possible" to provide a safe working surface on the right-of-way but recognizes that in some sensitive permafrost areas topography may dictate use of cut grades (Section 13.a.6.5.1, p.39). Erosion control categories shown on the "Alignment Sheets" include category EC-7L (Section 8.b.1.3.8, p.67) for areas "where some degree of cut-grading is essential in order to permit passages of construction equipment over severe changes in gradient", but unfortunately the erosion control categories are omitted from the "Alignment Sheets" at most of the places where such cut-grading might be used (i.e. crossings of river valleys).

Information Required

The Applicant is requested to elaborate further on right-of-way cuts in sensitive permafrost areas by providing the following:

1. Maximum acceptable gradient along the right-of-way on a snow or ice working surface and on a cut-grade working surface for (a) pipe construction, laying, and testing and (b) transportation of materials.

2. Document with several actual examples, the kinds of situations where right-of-way cuts would be needed in sensitive permafrost areas to establish working grades, the depth of such cuts, the nature and extent of site investigations at these cut sites prior to excavation, and how the data so obtained would be used in restoration, erosion control and preservation of stability.

3. Locate on the "Alignment Sheet" profiles those valleys where cut-grading would be required (i.e. localities at which EC-7L would apply).

4. Illustrate with specific examples, situations (if any) where the steepness of the right-of-way might require construction of temporary roads off the right-of-way to facilitate movement of construction materials along the route.

No. 19

SITE INVESTIGATIONS REQUIRED FOR DESIGN

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Information Required

Additional geotechnical, geothermal, hydrologic, and other data will be obtained by the Applicant prior to completion of his final designs.

The Applicant is requested to provide a comprehensive statement of principles and criteria that would be used in determining the kind and amount of additional site investigations, sampling, and analysis to be undertaken for the final design. Reference should be made to local effects of topography, terrain type, vegetative cover, etc.

No. 20

TERRAIN STABILITY, SOUTHERN PART OF PERMAFROST REGION

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Environmental Guideline 2: "that construction, operation and abandonment of a pipeline will be done so as to avoid or minimize adverse effects upon the surrounding terrain including vegetation, and aesthetic damage to the landscape;"

Background

The Applicant proposes to refrigerate the pipeline in the southern part of the NWT where the route would cross both unfrozen ground and ice-rich permafrost, including areas of intermingled frozen peat plateaux and thaw depressions. Both the permafrost and non-permafrost areas are at temperatures very close to freezing. A slight temperature rise could lead to differential subsidence and pipe buoyancy, whereas the reverse could result in heave or frost-induced blocking of drainage. Although the Applicant makes general reference to temperature-controlled changes in this region, he provides no plans for predicting or managing negative terrain effects.

Information Required

The Applicant is requested to illustrate his approach to the matter outlined above by:

1. Providing a sample geothermal analysis and thaw consolidation calculation involved in permafrost regression beneath a peat plateau; also geothermal analysis, "heave" and ice-buildup calculations for permafrost buildup in a formerly unfrozen depression.

2. Indicating the degree to which it would be possible to vary the operating temperature of his pipeline from time to time during operation and how this might be done to minimize thaw or heave and related effects.

No. 21

THAWING AND INSTABILITY OF DITCH BACKFILL PRIOR TO OPERATION OF CHILLED PIPELINE

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Environmental Guideline 2: "that construction, operation and abandonment of a pipeline will be done so as to avoid or minimize adverse effects upon the surrounding terrain, including vegetation, and aesthetic damage to the landscape;"

Background

The Applicant has referred generally to potential thaw-instability of backfill and control measures to stabilize backfill, but has provided no examples

of application in the various terrain situations occurring along the proposed pipeline route. In addition, there are some apparent inconsistencies in assumptions and data on which discussions are based. For example, a statement with respect to thawing of ditch backfill "Thermal studies indicate that, in the continuous and most northerly portions of the discontinuous permafrost zones, approximately north of Fort Good Hope, the depth of thawing of the backfill will not go beyond the mid-depth of the pipe, assuming four feet of cover, prior to the chilled pipeline going into operation" (Section 8.b.1.3.8.3, p.52) appears to conflict with data supplied by the Applicant (Section 8.b. 2.2.6, p.23-5) which show that average July and October ground temperatures "at half the depth of the pipe centre line", would be at $32^{\circ}F$ between Station CA-07 and CA-08 (at the north end of Richardson Mountains) and above $32^{\circ}F$ for all stations to the south and east.

Information Required

1. The Applicant is requested to provide a statement on the theoretical assumptions and geotechnical and experimental data involved in analysis of thaw stability of backfill.

2. The Applicant should illustrate by examples, the geotechnical, geothermal, climatic and slope conditions under which thaw stability analysis would be needed prior to construction.

No. 22

OFF-ROAD VEHICULAR TRAFFIC REQUIRED FOR CONTINGENCY REPAIRS

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Other Environmental Guidelines.

Background

Major pipeline repairs, especially replacement of a failed portion of the line could necessitate off-road movement of heavy equipment (Section 13.b.6.1.3, p.28) and could possibly involve serious damage to vegetation and terrain. Some intervals of terrain might not be negotiable by surface vehicles regardless of degree of damage. Movements of equipment and vehicles on the ground or by air might be restricted at certain seasons because of sensitivity of bird, mammal, or fish populations.

Information Required

1. Frequency, seasonality, and magnitude of pipeline repair events as inferred from pipeline maintenance experience elsewhere, modified by Applicant's assessment of climatic, terrain, and other factors on pipeline maintenance in permafrost regions.

2. The types and numbers of various pieces of equipment and transport vehicles required for the various classes of repairs, and the use to which each will be put. This information could best be provided in the form of hypothetical "case histories" of repair events.

3. Discussion of engineering, geotechnical or other considerations involved in selection of equipment and transport vehicles as tabulated in Tables c.1.1A, 1B, 1C, Section 13.b.

4. Technical specifications of the various "LGP" vehicles which Applicant proposes o use, including capabilities and limitations with respect to load, degree of slope, surface roughness, vegetation type, nature

and bearing strength of surface materials, and their probable effects on the various vegetation and terrain types encountered along the pipeline route north of 60^{O}N. Lat.

5. Analysis of seasonality of possible equipment and vehicle movements, whether by ground or air in order to relate such movements to seasonal sensitivity of bird, mammal and fish populations (as shown on Alignment Sheets and supporting texts).

No. 23

DIFFERENTIAL SUBSIDENCE (THERMOKARST)

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Background

The Applicant discounts the possibility of differential settlement: "The results (of Geothermal Analysis) have indicated that only stable soils with low moisture content and containing no excess ice possess the thermal properties necessary for the 32 degree Fahrenheit isotherm to regress to a significant depth below the pipe during two inactive summer periods." (Section 8.b.1.3.9.5.2, p.80). Further, the Applicant does not evaluate potential effects of naturally occurring subsidence on stability or integrity of the pipeline, or possible acceleration of such subsidence by disturbance following construction activities.

Information Required

The Applicant is asked to provide an analysis of the modes and rates of the natural thermokarst processes in terrain types subject to thermokarst activity and of the possible acceleration of thermokarst subsidence due to pipeline and related construction activities.

No. 24

BURIAL MODE OF CONSTRUCTION

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Environmental Guideline 2: "that construction, operation and abandonment of a pipeline will be done so as to avoid or minimize adverse effects upon the surrounding terrain, including vegetation, and aesthetic damage to the landscape;"

Information Required

The Applicant proposes to bury the entire pipeline (except for short above-ground sections at measuring and compressor stations), and to refrigerate the pipeline throughout its length within the Northwest Territories and Yukon Territory. He is asked to provide a comparison between this burial and chilling construction mode and alternative modes involving berm or pile construction with particular reference to potentially unstable slopes and to terrain with high potential for thermokarst subsidence.

No. 25

SNOW AND ICE ROADS

Guideline Reference

Environmental Guideline 2(b): "methods of minimizing removal of vegetation and the organic mat in permafrost areas of high ice content."

Background

The Applicant indicates that for all spreads

where Arctic construction techniques are to be used, the preparation of snow and ice roads is to begin October 1, and the stringing of pipe within 1½ months of that date (November 15). The Applicant has also indicated (Section 8.b.1.3.5.2, p.24) that problems related to snow quality and quantity, and surface micro-relief, were encountered during road construction tests. There is concern that (a) similar problems—and therefore delays—may be encountered during actual construction and (b) strict adherence to the November 15 traffic schedule may result in removal of vegetation and the organic mat.

Information Required

The Applicant is requested to:

1. Outline the scheduling changes foreseen in the event that snowfall is inadequate and ice-road construction is not possible by November 15, and comment on the implications of the change.

2. Outline ice-road construction procedures to be used in the event that snowfall is inadequate for snow-pack construction and the manufacture of snow is not feasible.

3. Outline procedures to minimize surface disturbance across hummocky terrain of specified micro-relief.

No. 26
EARTHQUAKE DAMAGE TO PIPELINE

Guideline Reference

Environmental Guideline 2(a): "methods of handling potential problems in relation to earthquakes, landslides, avalanches, or terrain changes resulting from thawing of frozen ground;"

Information Required

The Applicant proposes to use a modified ditch cross-section and special backfill to reduce earthquake-induced damage to the pipe in *bedrock* areas where earthquake risk is a concern. Further in this regard, he is asked to comment on:

1. Possibility of need for similar adjustments in ditch-form to reduce earthquake damage where the pipe passes through frozen ice-rich soil materials.

2. Procedures for avoiding ice build-up in the special backfill material proposed for earthquake-sensitive sites.

3. Hazards to pipeline from earthquake-induced slope failures, and procedures to reduce such hazards.

No. 27
CONVENTIONAL AND ARCTIC CONSTRUCTION METHODS

Guideline Reference

Environmental Guideline 2(b): "methods of minimizing removal of vegetation and the organic mat in permafrost areas with high ice content;"

also *Environmental Guidelines 2(d), (e), (f).*

Background

The Applicant has indicated that special Arctic construction techniques will be widely used northward from approximately Latitude 65 degrees where permafrost conditions are considered to be severe, whereas conventional construction techniques will be applied farther south where permafrost conditions are inferred to be less troublesome (Sections 13.a.6, 14.d.N.5.3.1). However, the Applicant

does not discuss the criteriea that he will use in reaching local decisions on where Arctic or conventional construction methods will be applied.

Information Required

The Applicant is requested to indicate the criteria that would be used in reaching local decisions on use of Arctic construction methods as opposed to conventional construction methods and to illustrate his use of these criteria by reference to specific examples from actual local situations on his proposed right-of-way.

No. 28
NATURAL SLOPE STABILITY

Guideline Reference

Environmental Guideline 1: "that a pipeline be constructed*, operated and abandoned in keeping with good engineering practice to ensure its safety and integrity, in the interests of good environmental management and the reduction of environmental damage;"

Environmental Guideline 2(f): "methods of maintaining slope stability in general;"

Background

The Applicant has described a method of slope stability analysis (Section 8.b.1.3.2.4) and has stated that the alignment has avoided potentially unstable slopes (Section 14.d.N.6.3.2).

Information Required

The Applicant is asked to provide the analyses or calculations that have been made to demonstrate that the steeper slopes along the alignment are stable (i.e. not "marginally stable"), using specific sites as examples to illustrate the approach.

No. 29
BORROW SOURCES

Guideline Reference

Environmental Guideline 2(i): "quantity and quality of aggregate or borrow materials required, details of the geographical distribution of the requirements and proposals as to sources of the required material, including proposed access routes from pit or quarry to point of use, and restoration of pits and quarries;"

Information Required

The Applicant is requested to provide, insofar as possible at this stage of project planning, the following additional information about individual borrow sources and borrow pits.

1. Photomosaic maps showing the locations of all borrow sources and access roads that do not appear on the present "Alignment Sheets". These photo maps should be on the same scale as the "Alignment Sheets".

2. Approximate outline or extent of each pit; average or typical depth; period of use (time of year, by month) and duration.

3. Nature of material to be drawn from each pit, grades of material, and approximate quantity of each grade to be drawn from each source and the planned use of these materials.

No. 30
FOAM INSULATION TO STABILIZE PERMAFROST

Guideline Reference

Environmental Guideline 2(f): "methods of maintaining slope stability in general;"

Background

The Applicant has indicated that there will be certain areas along the pipeline right-of-way where some type of artificial insulation will be required to ensure the stability of permafrost-affected slopes during revegetation (Section 8.b. 1.3.8.4.2, p.70). He proposes to cover sheets of foam insulation with six inches of granular fill and top soil to stabilize the foam and provide adequate growth-conditions for revegetation. However, no evidence is furnished to support the effectiveness of the procedure.

Information Required

The Applicant is requested to provide evidence that:

1. the overlying fill can, in fact, stabilize the foam,

2. the foam at a depth of only six inches will not inhibit revegetation or rooting,

3. the foam and achievable revegetation can provide adequate long-term insulation.

No. 31

CRITERIA FOR REVEGETATION PROCEDURES

Guideline Reference

Environmental Guideline 2(j): "plans to carry out assisted revegetation or alternative methods of providing an insulating cover on which natural revegetation can occur;"

Background

The Applicant has provided some information on the revegetation plans for the pipeline right-of-way (Alignment Sheets and Section 8.b.1.3.8.4.1, p.61). It is not apparent, however, from this information why a specific procedure has been proposed for a particular section of the right-of-way. For example, the seed mixture designated as Code 2-V-2 for use on moist, moderately well drained sites has been applied to all terrain types on Alignment Sheet 1B-0200-1002. These terrain types include HM, PT, KT, RKM—some GLB-1, RKM(SL) and GLB-1 (SL). On the subsequent sheet (1B-0200-1003) this revegetation procedure is also applied to terrain type GLB-2.

Information Required

The Applicant is requested to explain the criteria used to determine the rationale of the various revegetation procedures. This should include the relationship between the various terrain types, as identified on the Alignment Sheets and the site descriptions for which the seed mixtures have been specified.

No. 32

REVEGETATION SPECIFICATIONS

Guideline Reference

Environmental Guideline 2(j): "plans to carry out assisted revegetation or alternative methods of providing an insulating cover on which natural revegetation can occur;"

Background

The Applicant states in Section 14.d.2.2.1, p.8 "Fulfillment of Northern Pipeline Guidelines", that all areas disturbed during construction and operation will be revegetated where plant growth is feasible and that the specifications for revegetation appear on the Alignment Sheets. These specifications are incomplete for certain situations.

Information Required

The Applicant is requested to provide revegetation specifications for:

1. pipeline sections 1A, 1C, 1E, and 1J,

2. organic terrain,

3. borrow areas,

4. all areas such as staging sites, etc. not included on the Alignment Sheets.

No. 33

Replacement and Revegetation of Tundra

Guideline Reference

Environmental Guideline 2(j): "plans to carry out assisted revegetation or alternative methods of providing an insulating cover on which natural revegetation can occur;"

Background

The Applicant indicates that as an aid to revegetation, the upper tundra layer will be removed before excavation and replaced subsequent to backfilling (Section 13.a.6.5.4, p.41). There is concern about the effectiveness of this procedure. Experimental studies on tundra removal and replacement are described in "Biological Report Series, Vol. 2, Pipeline Revegetation". The proposed procedures differ so widely from the experimental studies that there is need for more precise information on the former.

Information Required

The Applicant is requested to supply supportive documentation for the revegetation technique proposed. This should include:

1. the regenerative ability of plant remains in the organic layer following its replacement on the pipelime berm;

2. the insulative properties of the replaced organic and vegetative material, compared with the adjacent undisturbed tundra;

3. the successional stages following replacement of the organic matter on the berm. Of special interest are the early changes in species composition;

4. effectiveness of reseeding programs on tundra involving agronomic species.

No. 34

REVEGETATION USING EROSION-CONTROL MAT

Guideline Reference

Environmental Guideline 2(j): "plans to carry out assisted revegetation or alternative methods of providing an insulating cover on which natural revegetation can occur;"

Background

The Applicant has indicated that for Section 1B of the pipeline approximately 23 miles of right-of-way will be revegetated and stabilized using an erosion-control mat pegged down with willow and alder cuttings and seeded with seed mix 2-V-2 (Section 8.b.1.3.8.4.1, p.68).

Information Required

The Applicatn is requested to provide further information on this procedure, including planting densities, source of cuttings, type and quantity of matting, man-hours required (Biol. Rept. Ser. Vol. 2, p.21 indicated 600 man-hours/acre), type and frequency of transportation between camps and planting sites, timing, etc. For illustrative purposes a specific example, such as Chainage 1.14 to 2.01, Sheet 1B-0200-1005, is suggested, approximately 10 acres.

No. 35

"MINOR" STREAM CROSSINGS

Guideline Reference

Environmental Guideline 3: "River and lake

crossings", generally.

Environmental Guideline 4: "River and lake regimes", generally.

Background

The Applicant provides four "typical stream crossing profiles" (Design Drawings, drawing 4-0210-1099) for "minor" river crossings, but does not describe the manner in which these sketches will be converted into specific plans for actual crossings sites.

Information Required

The Applicant is asked to specify the information he would obtain as the basis for his design specifications for a "minor" river crossing (river-bed profile; flood levels and predictions; scour calculations; bank stability; geotechnical data on bed, bank and valley-wall materials; groundwater and permafrost occurrence, etc.) and also indicate how such information would be used in determining precise crossing location, buoyancy control, erosion control, slope stability, pipe anchors, etc. The following stream crossings should be used as examples:

1. Stream crossings at Segment 6, Alignment Sheet No. 1A-0200-1008.

2. Thunder River, Segment 2, Alignment Sheet No. 1B-0200-1005.

3. Blackwater River, Segment 5, Alignment Sheet No. 1B-0200-1032.

No. 36

RIVER SCOUR DEPTH AT CROSSINGS

Guideline Reference

Environmental Guideline 3(a): "for river or stream crossings to be installed beneath the watercourse, depth of maximum anticipated scour and depth of proposed placement of pipe, supported by bore-hole logs and other data indicating the scour depth;"

Background

The Applicant provides the assurance (Section 8.b.1.3.8.1, p.56-7) that the effects of floods and ice jams have been taken into account in estimating scour for the preliminary designs of the river crossings shown in Design Drawings, Section 8.b.3. However, no information appears to have been provided on how the scour was estimated.

Information Required

The Applicant is asked to provide:

1. A statement on his approach to estimation of scour depth and on his weighting of the various factors involved, particularly the effect of ice jams.

2. The calculations of scour depth that have been made in preparing the preliminary river-crossing profiles included in Design Drawings, Section 8.b.3 on drawings 1C-0210-1001, 1E,-210-1001, 1E-0310-1003, 1A-0210-1001, 1B-0210-1007, 1B-0210-1017, and 1B-0210-1018.

3. A listing of the kind and amount of additional information that he expects to obtain to refine his scour calculations in preparing his final designs for these crossings.

No. 37

MAJOR RIVER CROSSING DESIGNS

Guideline Reference

Environmental Guideline 3(c): "design of underground crossings of rivers and streams that could withstand the effects of runoff, bank erosion,

meander cutoffs, lateral migration of stream channels, ice jams, and icings, the magnitudes of which should be calculated according to reasonably expected extremes for a particular stream-crossing area;"

Background

The Applicant provides the assurance that this concern has been taken into account (Section 8.b. 1.3.8) in the preliminary designs prepared for river crossings, illustrated in Design Drawings, Section 8.b.3. However, the rationale leading to the selection of the particular designs does not appear to be provided.

Information Required

The Applicant is asked to provide:

1. A detailed statement on the application of his design concepts for river crossings as used in preparation of the crossing profiles of Firth River (Design Drawings, drawing 1C-0210-1001) and of Mackenzie River at Burnt Island (Design Drawings, drawing 1B-0210-1017) (Section 8.b.3). This statement should complement information provided in answer to the request on river scour.

2. A sample of a hypothetical, fully detailed river-crossing design, based upon the Mackenzie River crossing at Burnt Island with supporting information and analysis in sufficient detail to illustrate the rationale of the decisions involved.

No. 38

EFFECT OF PIPE LAYING AND CHILLED PIPE OPERATION ON RIVER BED DURING WINTER

Guideline Reference

Environmental Guideline 3(c): "design of underground crossings of rivers and streams that could withstand the effects of runoff, bank erosion, meander cutoofs, lateral migration of stream channels, ice jams, and icings, the magnitudes of which should be calculated according to reasonably expected extremes for a particular stream crossing area;"

Environmental Guideline 4: "that a pipeline will be constructed, operated and abandoned with a minimal disruption to river and lake regimes, water quality, and feeding, reproduction and migrating stages of fish and other aquatic organisms,"

Background

In certain streams, winter flow of water is mainly or entirely through permeable sand or gravel beneath the stream bed. Development of a frost bulb around a chilled pipeline buried beneath the stream channel could constrict or cut off entirely such flow. Primary concern relates to rivers (e.g. Malcolm or Firth) where subsurface flow appears to sustain channel flow downstream that may be used by overwintering fish. A second concern is that constriction of subsurface flow could initiate aufeis development, with direct effects on nearby structures or facilities (e.g. highway bridges or culverts), and possible secondary effects on channel stability, depth of scour, etc.

There is additional concern that ditching or backfilling operations involved in laying the pipeline beneath such stream beds in winter may result in interruption or restriction of subsurface flow, with comparable (but shorter term) effects.

Information Required

The Applicant is asked to provide a technical analysis of the probable effects on water flow, icings, and overwintering fish resulting from operation of a chilled pipeline beneath a stream bed in which winter flow is mainly or entirely

in the subsurface. The analysis should have regard to geologic conditions such as thickness and character of sub-channel materials and extent of permafrost; hydrologic factors such as permeability of bed materials, volume of subsurface flow, and water temperature; and pipeline factors such as the location of compressor chilling stations relative to crossing site and its effect on gas temperature.

The Applicant is further asked to provide an analysis of the effects on water flow, icings, and overwintering fish resulting from ditching, backfilling or other construction activities involved in laying a pipeline beneath the bed of a stream in which winter flow is mainly or entirely in the subsurface.

No. 39

BORROW PITS ON FLOODPLAINS

Guideline Reference

Environmental Guidelines 4: "that a pipeline will be constructed, operated and abandoned with a minimal disruption to river and lake regimes, water quality, and feeding, reproduction and migrating stages of fish and other aquatic organisms;"

Environmental Guideline 4(d): "methods of minimizing the addition of sediments and introduction of oils and greases into water bodies as a result of preconstruction and construction activities, particularly in respect to access roads and ice-bridges;"

Background

The siting of borrow pits on active flood plains or in locations very near watercourses is of environmental concern because the quarrying operations, rehabilitation procedures, and associated changes to stream channels may increase silt levels to a point harmful to fish and benthic organisms. The Applicant states that "present plans call for the removal of gravel from inactive flood plains only" (Section 14.d.N.7.7.1(iv)) and that the majority of borrow pits will be developed and worked in the winter season (Section 13.a.6.4.2). However, several borrow pits appear on the "Alignment Sheets" to be located close to rivers, thereby giving cause for concern. These include pits: on the alluvial meander plain (AMP) of the Martin River (Sheet 18-0200-1048); partly on the active flood plain (AFP) and partly on the fossil flood plain (FFP) of the Malcolm River (Sheet 1C-0200-1003); on the AFP of the Firth River (Sheet 1C-0200-1004); on the alluvial fan deposit (AFD) of the Blow River (Sheet 1C-0200-1009); on the AFP of the Rapid Creek (Sheet 1C-0200-1010); on the AMP and AFP of the Willow River (Sheet 1C-0200-1015); and partly on the AFT and FFP of the Rat River (Sheet 1C-0200-1017).

Information Required

For each of the sites listed above, the Applicant is asked to provide a statement on the effect of his proposed borrow operation on:

1. silt concentration in the river downstream from the site at different times of year;
2. aquatic habitats and fish and benthos populations, both long term and short term;
3. river-bed groundwater quality and flow in situations where overwintering fish are dependent upon the water moving through river-bed gravel.

No. 40

RESIDUE IN PIPE TEST FLUIDS

Guideline Reference

Environmental Guideline 4: "that a pipeline will

be constructed, operated and abandoned with a mimimal disruption to river and lake regimes, water quality, and feeding, reproduction and migrating stages of fish and other aquatic organisms;"

Environmental Guideline 4(e): "proposed location, volume, composition and disposal of pipeline test fluids;"

Background

Waste pipeline test fluids could constitute a danger to water quality and a hazard to aquatic organisms. The Applicant indicates that either water or water-methanol mixtures are to be used as pipeline test fluids, and certain disposal arrangements are described to ensure that watercourses do not receive fluids at temperatures appreciably above 32°F or greater than one per cent in respect to methanol content (Sections 13.a.7; 14.d.N.4.3.2; 14.d.N.7.7.4). It is not apparent, however, that these fluids receive any purifying treatment or that their volume has been considered in relation to the flow of the watercourse into which the fluid is to be disposed.

Information Required

The Applicant is requested to provide information of the probable residues in the pipeline test fluids, the locations and times of year when disposal would occur, the procedures to be used to lower the content of such residues to acceptable levels, and the precautions that are planned so that the volumes of fluid discharged into a watercourse would not harm fish and other aquatic organisms.

No. 41
CULVERT DESIGN

Guideline Reference

Environmental Guideline 4(a): "methods for construction of stream and river crossings in a way that will minimize interference with fish passage or degradation of aquatic habitats through erosion and sedimentation;"

Background

For roads crossing watercourses necessitating the installation of culverts it is necessary that culver design be related to water flow in such a way as to permit the continued passage of fish. Although the Applicant states that culvert design and size will meet this concern (Sections 8.b.1. 3.8.4.1.b, p.64; 8.b.1.4.5; 14.d.N.7.7.6) it is not apparent how the various considerations are to be taken into account to determine culvert design.

Information Required

The Applicant is requested to select a specific location as an example to demonstrate how culvert design and installation would ensure that water velocity, space considerations, and "high-drop" (at the downstream end of a culvert) would not hinder the passage of fish. The method and data base for calculation of the design flood flow should also be provided.

No. 42
METHODS TO CONTROL SILTATION

Guideline Reference

Environmental Guideline 4(a): "methods for construction of stream and river crossings in a way that will minimize interference with fish passage or degradation of aquatic habitats through erosion and sedimentation;"

Background

The harmful effects of silt on invertebrates and all life-history stages of northern fish is recognized by the Applicant in his supporting data. Nevertheless he does not indicate the specific methods he will utilize to ensure a minimum of

introduction of silt into waterbodies at pipeline crossing sites in general, and at winter crossing sites at, or close to, designated fish overwintering areas in particular.

Information Required

1. The Applicant is asked to supply detailed information on methods to control siltation of waterbodies, using the following river crossing sites as examples:

   Babbage River (YT)
   Donnelly River (NWT)
   Willowlake River (NWT)

2. In view of the proposal to cross Hodgson Creek (NWT) during the winter within a designated fish overwintering area, information should be provided on the special precautions to be taken in this case to prevent the degradation of habitat and possible loss of fish by the introduction of silt during this critical phase of the fishes' life history.

No. 43
SCHEDULING AND ENVIRONMENTAL CONSEQUENCES OF DELAYS

Guideline Reference

Environmental Guideline 4(c): "schedules of construction activities and evidence that the project contains the flexibility to allow pipeline, road, or other construction to cease for periods of time when important areas critical to fish, wildlife, or waterfowl are temporarily threatened;"

Environmental Guideline 2: "that construction, operation and abandonment of a pipeline will be done so as to avoid or minimize adverse effects upon the surrounding terrain, including vegetation, and aesthetic damage to the landscape;"

Background

The Applicant has provided assurances that his *planned* schedule of construction and other activities will be appropriately adjusted to avoid those times of year that are of particular concern for protection of fish, wildlife or waterfowl (Sections 14.d.N.2.2.3; 13.a.2.0). Of equal concern are potential environmental disturbances resulting from the unplanned or unanticipated changes in schedule that could arise from delays caused by inclement weather, difficult terrain, equipment problems, personnel problems, etc. This concern relates both to protection of biologically sensitive sites at particular times of year and to maintaining schedules needed to prevent permafrost and backfill instability prior to refrigeration of the pipe.

Information Required

The Applicant is asked to comment on the effect of delays, such as those referred to above, on his planned schedules, and to indicate how he would meet requirements for environmental protection in adjusting his schedule to accommodate such delays.

No. 44
FISH MIGRATION

Guideline Reference

Environmental Guideline 4(a): "methods for construction of stream and river crossings in a way that will minimize interference with fish passage or degradation of aquatic habitats through erosion and sedimentation;"

Background

Although substantial river-structures may only modify a stream channel they may exercise a serious

deterrant effect upon normal fish migration during the early and late summer season. The Applicant describes river-structures that appear to fall into this category for various major rivers (Section 13.a.6.5.11), but it is not known whether their deterrent effects have been taken into account.

Information Required

The Applicant is requested to provide evidence that the temporary structures described in the above-mentioned Section would have no serious deterrent effects upon fish migrations and would not induce a longer term reduction in fish populations.

No. 45
EFFECTS OF BLASTING ON FISH

Guideline Reference

Environmental Guideline 4(a): "methods for construction of stream and river crossings in a way that will minimize interference with fish passage or degradation of aquatic habitats through erosion and sedimentation;"

Background

Blasting can seriously harm aquatic organisms, including fish, either directly through the transmission of shock waves, or indirectly through siltation of habitat. The Applicant has indicated that, where necessary, blasting will be employed for trench excavation, both for river crossings themselves and for the approaches and banks of rivers (Sections 13.a.6.5.4; 13.a.6.5.11).

Information Required

The Applicant is requested to provide information on blasting procedures used in the above situations and on the measures that would be taken to protect fish and other aquatic organisms from direct and indirect damage from blasting.

No. 46
WINTER MIGRATION—PORCUPINE CARIBOU HERD

Guideline Reference

Environmental Guideline 5(a): "methods of minimizing the restriction of movement of wild animals such as caribou;"

Background

The migration routes of the Porcupine Caribou herd have been described for 1971 and 1972 in the Biological Report Series, Vol. IV. The Applicant has stated that "except for an area between the Yukon-Northwest Territories boundary and the Mackenzie Delta, winter construction along the proposed route will avoid interaction with caribou in all winter habitats" (Section 14.d.N.7.9.1, p.50). Data for subsequent years, however, have indicated much more varied winter movements. A contingency plan is proposed in Vol. V of the Biological Report Series (pages 174-175), but does not appear to have been adopted or referred to in Section 14.d.N, the Environmental Statement.

Information Required

The Applicant is requested to review all available data for the winter movements of the Porcupine Caribou herd in 1972-73 and 1973-74 and to furnish a revised estimate of movement patterns. Requested also are contingency plans that would ensure minimal interference with caribou should their pattern of winter movement bring them into close proximity to construction operations.

No. 47
EFFECT OF ANIMALS ON REVEGETATION

Guideline Reference

Environmental Guideline 5(a): "methods of minimizing the restriction of movement of wild animals such as caribou;"

Background

The Applicant has indicated that when the pipeline right-of-way is revegetated caribou may feed preferentially on a particular introduced grass (Section 14.d.N.7.6, p.16). The same can be said of moose and Dall's sheep, and there is concern, therefore, that the normal movement patterns of these animals may be deflected. Moreover, caribou may so graze, trample and retard the development of an insulating vegetative cover over the pipeline berm (Section 14.d.N.7.6, p.16) that erosion could be initiated with the eventual formation of a ditch along the pipeline.

Information Required

The Applicant is requested to describe the contingency plans that would be implemented should problems of the above nature arise and the deflection of movement patterns of caribou and other animals occur.

No. 48

NORTH SLOPE HABITAT OF SNOW GEESE

Guideline Reference

Environmental Guideline 5(b): "methods of protection of wetland areas used as feeding, breeding and staging areas by migrating waterfowl or as habitat for fur-bearers;"

Background

In reference to the timing of activities on the Yukon North Slope insofar as they might affect waterfowl, the Applicant states that: "...unloading and staging activities will occur in late August and early September, thereby not interfering with breeding and nesting" (Section 14.d.N.7.8.1, p.37). In Section 14.d.N.4.8.3, page 73, the Applicant states that snow geese "scatter all over slope, moving inland as far as and into foothills. Known to be highly sensitive to ground-based noise and aircraft disturbance."

Information Required

The Applicant is requested to provide appreciably more data on the distribution and timing of the presence of snow geese on the North Slope, particularly the significance of the North Slope goose staging area in relation to alternate resting and feeding sites. Specific information is required on the possible consequences of unloading and staging operations of the Applicant during the August-September period and what measures would be taken to minimize disturbance of geese during this period.

No. 49

DISTURBANCE OF MUSKRAT AND BEAVER

Guideline Reference

Environmental Guideline 5(b): "methods of protection of wetland areas used as feeding, breeding, or staging areas by migratory waterfowl or as habitat for fur-bearers;"

Background

The Applicant states that with beaver "areas of potential disturbance are relatively small... (and) may be avoided by minor alterations in pipeline route alignment...on the basis of on-site environmental guidelines" (Section 14.d.N.7.9.7, p.54); and with muskrat "any appropriate protective measures found to be necessary will be taken" (Section 14.d.N.7.9.7, p.54).

Information Required

The Applicant is requested to explain more precisely what is meant by such terms as "minor alterations", "on-site environmental guidelines", and "appropriate measures" when used in the above contexts.

No. 50
EFFECTS OF BLASTING ON WILDLIFE

Guideline Reference

Environmental Guideline 5(c): "methods of minimizing harassment and other impact upon wildlife populations from greatly increased human intrusion and the operation of boats, ground vehicles, aircraft, and compressor or pumping stations;"

Background

The Applicant has stated "where blasting is required for excavating of the ditch, precautions will be taken to prevent injury or damage to any wildlife, person or property" (Section 13.a.6.5.4, p.41). There is particular concern in respect of wildlife.

Information Required

The Applicant is requested to provide the following information:

1. The factors to be considered in identifying situations under which blasting would disturb (a) Dall's sheep, (b) raptors, and (c) other wildlife.

2. What are the locations or situations where such disturbance may take place.

3. What measures would be taken to avoid these hazards.

No. 51
RAPTOR NESTING SITES

Guideline Reference

Environmental Guideline 5(d): "safeguards proposed and alternatives that were considered for the habitats of rare or endangered species;"

Background

Although the Applicant has stated "Raptor sites have been identified and avoided in facilities locations" (Section 14.d.N.6.3.6, p.10), it is acknowledged that the "Prime Route passes within three miles of 16 raptor nests" (Sect. 14.e.1.2.3.2.b, iii, p.115). It appears, also, that at least 106 miles of pipeline alignment, three compressor stations, 12 borrow pits, one staging site, one communication tower, three helipads and three airstrips are located within areas designated as rare and endangered breeding sites in the Wildlife Map Series, quite aside from an area whose boundaries embrace part of the Mackenzie Delta.

However, the possibility that on-going studies will reveal further nest sites and that realignment of the right-of-way may be necessary is recognized by the Applicant—"On-going studies are being made to locate further nest sites of these species that may lie in proximity to the proposed route. Where possible, these will be avoided by adjustment of pipeline alignment. Where not possible, construction activity and other disturbance will be scheduled to minimize impact during the critical nesting period (site selection to avoid fledging of young)" (Section 14.d.N.7.8.2, p.43). And—"construction within at least 2.5 miles of nesting cliffs should be avoided between March 1 and August 15" (Section 14.d.1.2.2.2.b, iii, page 82).

Information Required

1. The Applicant is requested to define the terms—"where possible", "avoided", "adjustment of pipeline alignment" as used in the above contexts, and the circumstances under which realignment is "not possible". The

"protective safeguards" planned should be explained, with special mention of aspects such as scheduling and minimum working distances from active nesting areas.

2. The Applicant is requested to illustrate the above by reference to relationship of compressor station CA05, mile 223.8 (and the associated airstrip) to the nearby bluffs along Malcolm River identified on Alignment Sheet 1C-0200-1003 as "Critical habitat for rare to rare and endangered species breeding; highly sensitive from March to August. All disturbance of breeding area will be avoided." Information should be included regarding alternative facility locations farther from the critical habitat that have been considered and the rationale for selection of the proposed site.

No. 52
WATER CONSUMPTION

Guideline Reference

Environmental Guideline 6(a): "methods of waste disposal to avoid health hazard to humans and animals as well as aesthetic pollution; information should be provided on use of water from streams, springs or lakes for domestic, camp or construction purposes and on location of camps and sewage disposal systems relative to local drainage patterns;"

Background

The Applicant has provided over-all figures for the consumptive use of water for various purposes on a seasonal basis for a three-and-a-half year period (Sections 13.a.5.4; 8.b.1.4.6; 13.b.5.6.2; 14.d.N.5.3.1; 14.d.N.5.3.2; 14.d.N.7.3; 14.d.N. 7.7.5). What is not apparent, however, is a breakdown in consumptive use that can indicate the volumes of water to be taken from particular waterbodies and the design of the extractive facilities.

Information Required

The Applicant is requested to indicate tentative locations from which he would draw water (show on a map); the approximate quantity of water that would be taken from each; and the maximum rate of water use at each source, during the following pipeline construction work:

1. Spread C, winter 1978-79.

2. Spread E, winter 1976-77.

No. 53
SPILLAGE OF TOXIC MATERIALS

Guideline Reference

Environmental Guideline 4(d): "methods of minimizing the addition of sediment and introduction of oils and greases into waterbodies as a result of preconstruction or construction activities, particularly in respect to access roads and ice bridges;"

Environmental Guideline 6(c): "the nature, transportation and use of any pesticides, herbicides, pipe coating materials, anti-corrosion materials, flushing agents, or other toxic substances, proposed for the project, and information on their expected persistence and mobility in surrounding ecological systems;"

Background

The Applicant has indicated the total quantities of fuel, lubricants and methanol to be delivered each summer and winter over the period 1975-79, for each pipeline construction section of the route (Sections 13.a.3.1, Fig. 2; 13.a.5.4, Fig. 2). However, the quantities required at individual stockpile sites are not provided, likewise the mode and amount of hauling. There appears,

also, to be no information on the expected persistence and mobility of such potentially toxic substances should they enter the various ecological systems.

Information Required

The Applicant is requested to indicate:

1. Quantities of fuels, methanol, and other toxic substances to be used on a "spread".

2. Modes of storage of these materials at the stockpile site used for a particular "spread", methods of transfer of the materials to localities where they would be used or to subsidiary storage sites, and mode of storage at such sites.

3. Amount of loss of the various materials from spillage or wastage at the stockpile site and after removal from the stockpile site, that would arise during normal handling and storage operations.

4. Mobility and persistence of the various materials covered in No. 1, and procedures to contain and clear up spills.

5. Expected number of pipe ruptures during pipe testing, within the length of a "spread", and the maximum amount of water-methanol mixture that would be spilled during such a rupture, and method of containment and clean-up.

No. 54
CONTINGENCY PLANS—RIVER CROSSINGS

Guideline Reference

Environmental Guideline 8: "that effective plans be developed to deal with oil leaks, oil spills, pipeline rupture, fire and other hazards to terrestrial, lake and marine habitats, that such plans be designed to minimize environmental disturbances caused by containment, clean-up or other operations and to bring about adequate restoration of the environment, that they be designed to deal with minor and major incidents, whether they are single-event or occur over a period of time and that they include contingency plans to cope with major hazards or critical situations."

Background

Repairs to a pipeline at major river crossings could be lengthy and difficult with a potential for important economic and environmental consequences. The Applicant discusses line-repair procedures (Section 13.b.6.1) but these do not seem to be applicable to line breaks at river crossings.

Information Requires

The Applicant is requested to indicate the contingency procedure that he would use for repairs to the pipeline at a major river crossing, using that of the Peel River as an example. Included should be estimates of the amount of natural gas escaping before the affected pipeline length can be sealed off, and the possible toxic effects of this leakage on aquatic organisms downstream for both summer and winter breaks, and the possible hazards involved.

No. 55
MONITORING

Guideline Reference

Environmental Guideline 10: "that an effective pipeline performance monitoring system of inspection and instrumentation be established to ensure operational performance in keeping with the above-stated environmental concerns."

Background

The Applicant provides brief general statements about environmental inspection during the construction phase, post-construction research, and post-construction facilities inspection (Section 14.d.N. 6.1.2); he also mentions right-of-way surveillance providing "early detection of signs of erosion, slope instability, or any other potential threat to the system or the environment." (Section 14.d.N. 6.3.2.14). Review of the Applicant's plans in these regards is hampered by the absence of any specifics or details.

Information Required

The Applicant is requested to list and describe performance monitoring procedures that he would apply where necessary, and particularly procedures for repetitive or instrumental measurement of such things as sediment concentrations in water, toxic materials, slope movement indicators, permafrost regression or build up, pore pressures, flow velocity in culverts, fish and benthos populations, mammal and bird populations, progress of vegetation growth, and other parameters referred to in guidelines 1 to 9.

No. 56

PIPELINE STABILITY FOLLOWING INACTIVATION OR ABANDONMENT

Guideline Reference

Environmental Guidelines 1 to 5.

Background

The Applicant indicates that for permafrost areas an abandoned pipeline would be in stable soil and would remain "frozen in" in the permafrost (Section 14.d.N.6.5). However, if the stability of the ice-rich soil had been maintained by operation of the chilled line then cessation of chilling could lead to permafrost regression and subsequent instability of terrain. Similarly in areas of discontinuous permafrost, if a frost bulb had developed in the naturally unfrozen ground, thawing could occur, also leading to instability.

Information Required

The Applicant is requested to provide geothermal and other data to illustrate the potential effects of inactivation or abandonment of the chilled pipeline on frozen ground around the pipe, soil properties around the pipe and potential for erosion or slope failures.